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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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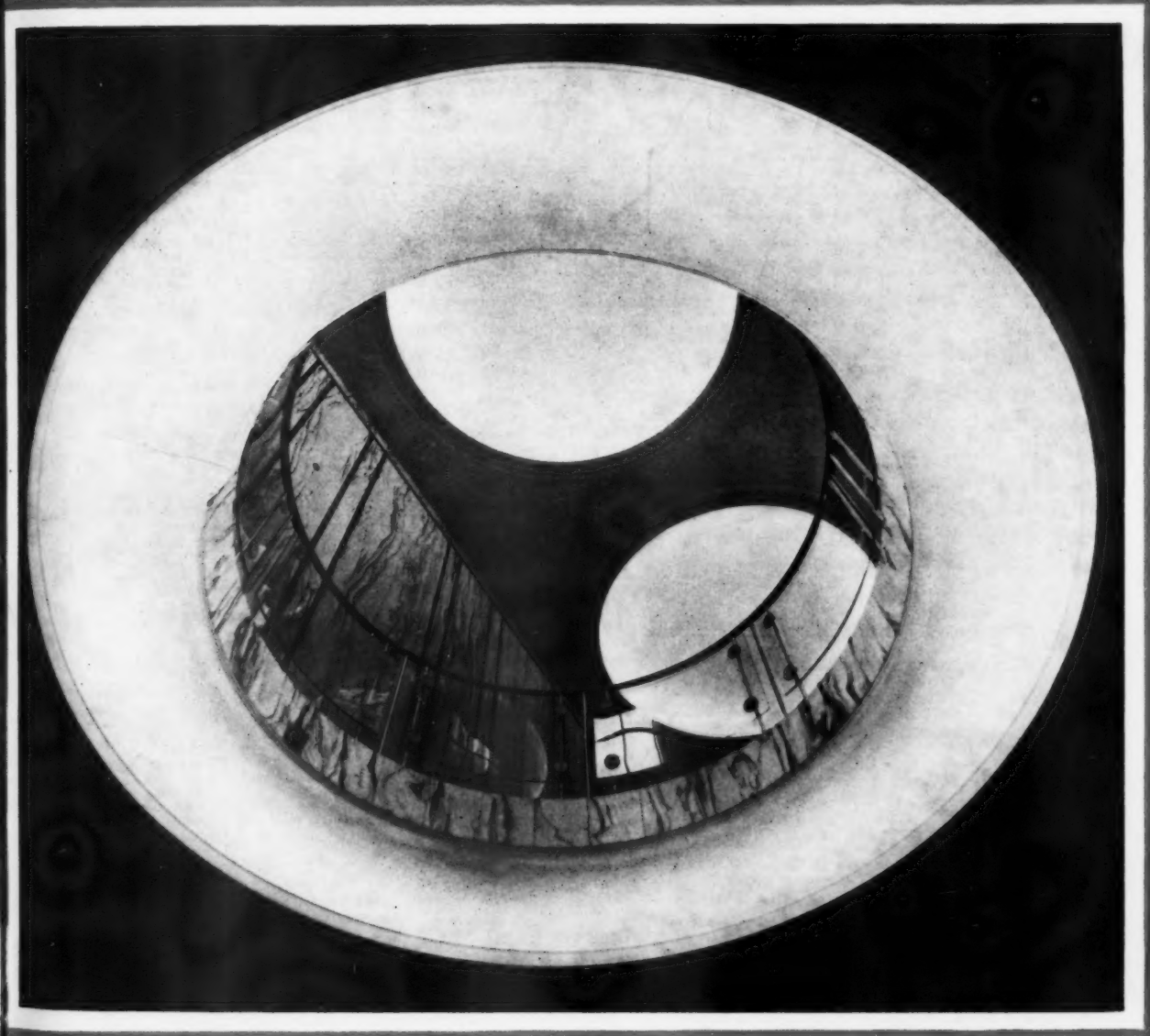

VOLUME 6 NUMBER SIXTY-TWO FEBRUARY 1960

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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Light and form

MORE than eight miles of cold-cathode tubing contribute to the interior lighting of the new Lloyd's building in London. The Underwriting Room alone—where up to 4000 brokers and underwriters carry out the insurance transactions—is fitted with 600 cold-cathode bowls and two laylights illuminated by over half a mile of continuous tubing. The cover picture this month shows a quieter corner of the building, the circular gallery over the south-west entrance staircase, looking upwards. Here indirect lighting is provided by cold-cathode tubes.

Much work is being done to rationalize the design procedure, and Mr. J. M. Waldram who is known particularly for his treatment of Gloucester Cathedral discusses 'designed-appearance lighting' in an article on p. 90.

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.
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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 6 NUMBER 62 FEBRUARY 1960

A GUIDE TO THE JOURNAL

WHAT does the *Journal* seek to do? Conversations with members have made it apparent that our publication procedures, and the relation of certain features in the *Journal* to one another and to the *Proceedings*, are often obscure to the reader.

The *Journal* aims to provide a balanced, non-specialist view of the whole realm of electrical engineering and also to act as a means of communication within The Institution. Most people agree nowadays that in science and engineering this interpretative function is very important and indeed one prominent scientist went so far the other day as to suggest that the Royal Society should invite into its membership one or two 'interpreters' each year. For our part, we would settle for the good opinion of our readers.

In carrying out this function we look first to the articles on various aspects of the technology which appear in the front 25 pages or so of each issue of the *Journal*. Apart from articles based on addresses and lectures presented to The Institution as a whole or to its Sections and Centres, the *Journal* commissions articles from knowledgeable people in various fields. The aim of these is to provide a balanced and reasonably even coverage of the whole world of electrical engineering, to furnish the technical background to the topical events of the day, and to open a window on related technologies and cultural subjects.

The *Journal* is here in many ways fortunate in being able to take advantage of the advice of various committees of The Institution and above all to tap the fund of goodwill which exists among members. Many busy men will write for the *Journal* who will not consider doing so for other organs of the Press. The articles themselves are intended to be easily assimilable, authoritative and generally useful and we are sanguine enough to believe that many readers find them so. Our effort is to make them brief because they are not meant to be definitive theses and because preoccupied engineers have to measure the 'apparent readability' of an article by the time it takes to read it. This may sometimes result in a certain sketchiness of coverage but against this must be set the fact that a larger number of shorter articles obviously can embrace a wider field and interest a broader section of the readership.

'Electrical engineering reviews' are published from time to time. These may be distinguished from the 'progress reviews' which appear in the *Proceedings* because they have the specific purpose of reviewing particular narrow fields of the art for the benefit of the non-specialist, whereas the 'progress review' has a wider range and serves particularly the interests of the specialist in the field with which it deals. Nineteen electrical engineering reviews have been published since the new *Journal* began in January 1955, covering subjects as diverse as television pick-up tubes, automobile ignition systems, high-capacity alternators, and wattmeters.

Our second look is at the sections of the *Journal* which give a synoptic picture of the *Proceedings*—the permanent record of The Institution. Here we have to distinguish, after the style of the medieval disputants, between the major and minor propositions. We can divide the *Proceedings*—Parts A, B and C—into (i) papers read at Institution meetings which are published as 'separates' before the meetings and later on included in a monthly part, as are the related discussions; (ii) papers published in a monthly part only and not read at meetings; and (iii) monographs, which are always first issued as 'separates', although not read at meetings, and then gathered together twice a year in Part C.

Without exception every paper and monograph of the *Proceedings* is reviewed in the *Journal*. Those in category (i) above are made the subject of short articles in the 'Review of the *Proceedings*'. The authors of the papers are particularly urged to make these articles as simple and straightforward as possible and they often include items of information not in the original papers. This is probably the place to point out that we usually arrange for the articles to appear in the same issue in which the reports of the meetings at which they are read are included in 'London report' or 'Bulletin of the Sections' in the 'news' section at the back of the *Journal*. Thus a report of the discussion is usually available with the article based on the paper.

The 'Review of the *Proceedings*' actually covers some

papers which may never appear in the *Proceedings* at all. These are papers by Students or Graduates which have been awarded premiums by the Council. In suitable cases the author of such a paper is invited to submit a short article based on it for publication in the *Journal*.

Another section of the 'Review of the *Proceedings*' embraces all the papers in category (ii) above (unread). Synchronizing with actual publication in Part A or B of the *Proceedings* we present here fairly short synopses, four or five to a page. Occasionally when a paper in category (ii) deals with a subject of general interest the author is invited to write a short article based on it. This article then appears in the first section of the 'Review of the *Proceedings*' at the same time as the original paper is published in the *Proceedings*.

But that is not all. As soon as a paper is published individually [see (i) above] we print a brief summary of it in the feature 'Papers and monographs published individually this month' so that members can decide whether to apply for copies before the meeting. The papers in category (iii) above (actually monographs) are similarly summarized in the same feature as soon as they appear in 'separate' form. Readers who do not take Part C of the *Proceedings* can write for these monograph 'separates' when they see them summarized in the *Journal*.

Finally we give a list of the contents of each current issue of the *Proceedings* for the benefit of those who may wish to obtain specific numbers or reprints of papers.

We think it is fair to claim that the *Journal* gives a full and sufficient guide to every Part of the *Proceedings*, though we have met few readers who are fully aware of this.

Our third 'look at all things as they are' must be at the rest of the *Journal*. Most of it needs no explanation. The book section aims to achieve comprehensiveness in the science, and few works of importance in English escape the net. This is something which seems especially to please oversea readers. 'Announcements to members' is deliberately kept official and formal, but the following 'news' section already mentioned can be rather more free and easy.

Incidentally, the 'news' section appears at the back of the *Journal* since the last 16 pages go to press a few days later than the front parts, not because the section is of notably less importance in our view than the earlier parts, but because this practice allows us to include later news in a section which we try to make topical.

Well, there it is—the *Journal* in the round. An imperfect account no doubt, but if it provides the reader with an explanation of why things are done as they are it will have served its purpose.

BRITISH CONFERENCE ON AUTOMATION AND COMPUTATION

THE Annual General Meeting of Group B—the British Group for Computation and Automatic Control of the British Conference on Automation and Computation was held on the 17th December 1959. The Honorary Officers were chosen and the Executive Committee was reconstituted for 1960 as follows: Chairman Mr. J. F. Coales, O.B.E., M.A.; Vice-Chairmen Mr. R. Hindle and Mr. H. W. G. Gearing; Honorary Treasurer Mr. S. M. Rix; Honorary Secretary Mr. W. Bamford, B.SC.; Committee members Dr. A. D. Booth, Mr. N. Clarke, Mr. E. C. Clear Hill, Mr. W. C. F. Hessenberg, Mr. N. C. Pollock and Prof. E. J. Richards. The Secretariat of the Group continues to be provided by The Institution of Electrical Engineers.

It was reported that resignations had been received from five member organizations who had indicated that at the present time the proportion of their activities which fell within the ambit of the Group did not justify the continuance of their membership. These organizations have been informed that the services of the Group remain at their disposal for the dissemination of information about any activities in its field that they may have in contemplation and that their return to membership will be welcomed when the volume of such activities supports this course.

The following is a revised list of the member organizations which now constitute Group B: The Association of Certified and Corporate Accountants, The British Computer Society, The Chartered Institute of Secretaries, The Institute of Actuaries, The Institute of Bankers, The Institute of Cost and Works Accountants, The Institute of Fuel, The Institute of Petroleum, The Institute of Physics, The Institution of Civil Engineers, The Institution of Electrical Engineers, The Institution of Mechanical Engineers, The Institution of Production Engineers, The Iron and Steel Institute, The Office Management Association, The Royal Aeronautical Society, and The Society of Instrument Technology; Observer: The Department of Scientific and Industrial Research.

One substantial activity which the Group has undertaken, in collaboration with Group A, is the sponsoring of the British contribution to the first congress of the International Federation of Automatic Control (I.F.A.C.) which is being held in Moscow from the 27th June to 6th July 1960 (see January 1959 *Journal*, p. 48, and December 1959 *Journal*, p. 704). As the number of papers submitted by British authors exceeded the time and space allocated by the organizers of the congress, arrangements are being made also for a British convention on this subject to be held in London in September 1960 at which the surplus of suitable papers will be presented.

Further details concerning the I.F.A.C. Moscow congress may be obtained from the Honorary Secretary, Group B, B.C.A.C., c/o The Institution of Electrical Engineers; the arrangements for the British convention referred to above are in the hands of the Honorary Secretary, Group A, B.C.A.C., c/o The Institution of Mechanical Engineers, by whom further announcements will be made.

An electrical engineering review

ELECTRICITY IN STEEL-MAKING

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This article gives an outline of an integrated iron and steel works and also refers to electric arc furnaces. The principal types of hot-rolling mill are mentioned. Descriptions are provided of the salient characteristics of the electric drives and of how power is supplied partly by generation (mainly from waste heat) and partly by the supply undertaking. Mr. Rolls is with McLellan and Partners.

T. B. ROLLS, MEMBER

THE modern integrated iron and steel works comprises a number of different plants brought together on one site to save transport and to enable the heat produced in one process to be used in another. Fig. 1 shows how the various items of plant are linked to form a single unit for the production of steel from raw materials. The annual output from such plants varies from a few hundred thousand tons to nearly three million tons.

Any interruption can cause far-reaching dislocation in the chain of production. Consequently not only is every effort made to ensure reliability but also the lay-out of the plant and the availability of spares are arranged to ensure a speedy repair in the event of a breakdown. Furthermore most works operate elaborate schemes of preventive maintenance, so that despite the arduous conditions in iron and steel works it is rarely that electrical equipment is responsible for delays.

Iron

The principal raw materials are coal and iron ore.

Coal after passing through a coal washery and blending plant is conveyed to the coke-ovens storage bunker, from which a charging car feeds the ovens. While the coal is in the ovens a rich gas is given off from which tar is removed by electrostatic precipitation and other by-products such as ammonium sulphate and benzol are extracted. The remaining coke-oven gas has a calorific value of about 500 B.Th.U./ft^3 and is used for process heating and steam-raising.

Along one side of the ovens runs a machine ejecting the coke after the process is complete. On the other side is a machine for guiding the coke into a travelling car propelled by an electric locomotive. The car is pushed to a quenching station where it is cooled by a discharge of water. This is responsible for the familiar white plume which at intervals is visible for miles around.

Some iron ore is mined in this country and some imported. Before reaching the blast furnace it is carefully graded and the 'fines' are sintered with coke breeze to form part of the charge.

The correct proportions of iron ore, sinter and coke, together with some limestone, are supplied to the blast furnace by means of an automatically controlled skip hoist. A general view of blast furnaces is shown in Fig. 2.

Up to this point the main use of electricity is for material handling. High-torque squirrel-cage motors predominate for conveyor systems which often entail elaborate sequence-control systems. For drives such as the pusher on the coke ovens and for wagon tipplers short-time-rated slip-ring motors are usual. Various forms of grabbing crane are used for unloading imported ore from ships. Owing to the high installed horse-power (approaching 1000), the distances involved and the need for accurate control, electricity may be supplied to such cranes at 3300 volts and used to operate Ward Leonard motor-generator sets.

Other large motors encountered are the coal crushers, say 500 h.p., and the sinter-plant fans (1500–2500 h.p.). The skip hoists on the blast furnaces usually have twin motors operated by either series–parallel or Ward Leonard control. The automatic control of the supply of iron ore, sinter, coke and limestone to the blast furnace is well worthy of the name 'automation' though such control was carried out long before that word was invented.

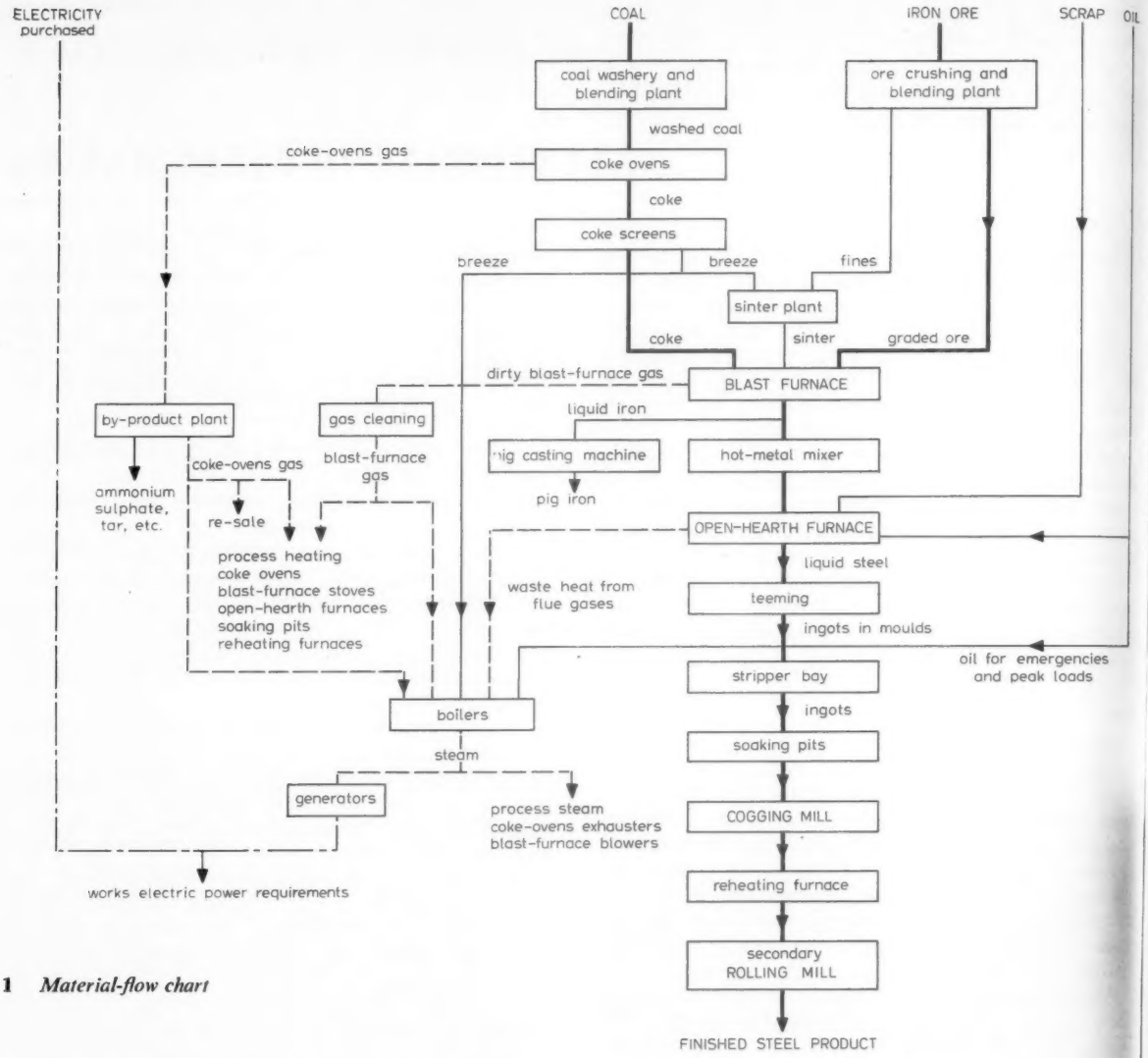
The varying combinations of heat, moisture, dust and a corrosive atmosphere make the operating conditions arduous for electrical plant.

The large quantities of air for combustion in the blast furnace are supplied by a turbo-blower, and this blast is heated by passing through stoves containing preheated chequered brickwork. The smelting process of the blast furnace produces a low-grade gas having a calorific value of about 90 B.Th.U./ft^3. After passing through dust catchers and being cleaned by electrostatic precipitators this gas is used for process heating and for raising steam. In turn, while some of this steam is required for processing, a large part is consumed by the steam turbines driving the turbo-blowers and for generating electricity.

The molten iron from the blast furnace is 'tapped' every few hours into ladle cars for transport to the steel-making plant.

Steel-making

For many years the most popular form of plant for steel-making in this country has been the open hearth in which the iron from the blast furnace is first poured into



1 *Material-flow chart*

a hot-metal mixer. From the mixer the molten iron is transferred by ladles into the open-hearth furnace; in addition special charging machines tip in boxes of scrap. The open-hearth furnace comprises a shallow bath in which incandescent gas or oil is played onto the surface of the charge; its carbon content being oxidized the iron becomes steel. The refining process in the open-hearth furnace takes 3–4 h. The steel is poured into ladles whence it is poured or 'teemed' into moulds.

The Bessemer convertor is an alternative method of producing steel from iron. The iron is poured into an egg-shaped vessel through which air is blown. The oxidizing reaction supplies the heat, the whole process taking only about 20 min after which the steel is poured into ladles for teeming. A modern development is to use oxygen for blowing the convertor.

When the steel in the mould has cooled, the ingot is stripped from the mould by a form of crane with fingers and a pusher. The steel is not yet ready for rolling as it is too cool on the outside and possibly still molten in the centre. The ingots are therefore transferred into soaking pits where they are heated until the temperature throughout is relatively uniform and where they can be stored until required for rolling.

The principal application of electricity in the steel-making process is to operate the cranes required for handling the ladles of hot metal, for stripping the ingots out of the moulds and for charging the soaking pits. Almost invariably these cranes are operated by direct current and in the larger installations may be capable of handling loads of 300 tons with something approaching 1000 h.p. of motors installed.

At present the electric arc furnace has little place in an integrated iron and steel works, in which the various other forms of heat are cheaper and for which indeed there may be no other economic outlet. Nevertheless electric arc furnaces continue to gain ground and are mainly used by the producers of special steels, a typical modern installation in this country being a 60-ton furnace supplied from a 15MVA transformer. Plans have recently been announced for a large arc-furnace installation which will replace an open-hearth shop for producing steel from pig iron and scrap.

Supplies to arc-furnace plants present special problems to the supply engineer, particularly because of the flicker on associated lighting circuits caused by the violently fluctuating current and because of the rather poor power factor caused by the need to have high reactance in the transformer to ensure a stable arc.

Cogging mills

When ready for rolling the ingots are withdrawn one, sometimes two, at a time from the soaking pits and fed into a cogging mill in which the steel ingot is passed backwards and forwards, the top roller being screwed down as the metal is reduced in size (Figs. 3 and 4). Reversing mills of this character are driven by the Ilgner form of Ward Leonard control in which the motor-generator set incorporates a flywheel to enable the mill motor to develop brief peaks of the order of 30000h.p. without causing disturbance to the electricity distribution system.

Sometimes the cogging mill is driven by a single large d.c. motor but in the more modern mills the upper and lower rolls are driven by separate motors mounted at different levels. To keep down the diameter and hence the inertia each motor of such a mill may be of the double-armature type.

With the growth of electricity distribution systems the heavy peaks of a reversing mill can be more easily absorbed and there is now a tendency to substitute rectifier drives for the Ilgner sets with their heavy flywheels.

3 *Two-high reversing cogging mill*

For heavy plates or steel sections (beams and rails) the ingot is rolled to and fro in one mill until it emerges with the required thickness or shape. Such a mill is usually referred to more simply as a plate, structural or beam mill.

Most of the steel however passes through one or more hot-rolling mills before it reaches the desired state and the terminology used in describing these mills is at first somewhat bewildering.

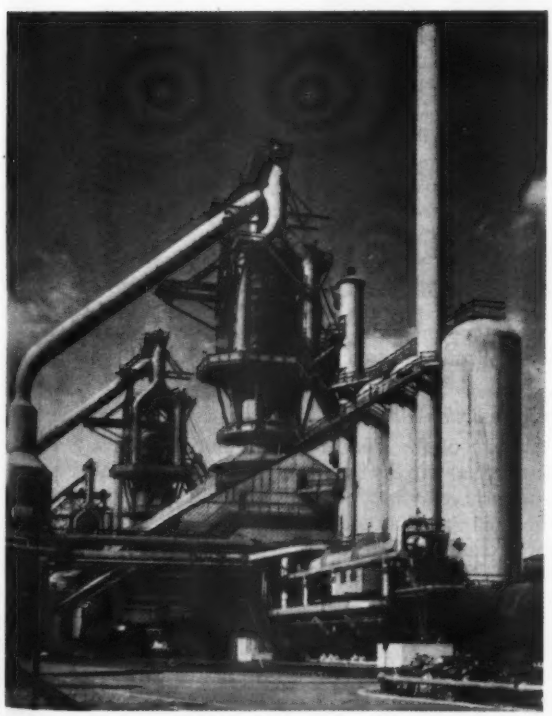
If the cogging mill is used entirely for reducing the ingot to slabs it is more generally referred to as a slabbing mill; if to blooms, sections about 10in. square, it is known as a blooming mill (even though at times it may produce slabs).

Rolling-mill motors

Apart from the impressive motors directly driving the rolling mill some reference must be made to the auxiliaries. First there is the screw-down drive which must be operated each time the metal has passed through the mill. High speed and great accuracy are essential and Ward Leonard control is employed. Similar considerations apply to the roller tables which feed the metal backwards and forwards into the mill, to the guides for feeding the metal into the proper place, and to the manipulators for turning the metal over. The generators for these Ward Leonard drives are grouped on one a.c. driving motor.

In rolling-mill practice the fitness of the drive to do the job is more important than its efficiency in the strict meaning of the word. The control and drive must be co-ordinated to ensure the maximum of metal through the mill in the minimum of time, and the provision of automatic programming equipment is beginning to reduce the dependence on the skill of the operators.

2 *Blast furnaces*



To accommodate the large amount of electrical power concentrated at a rolling mill a motor room has to be provided alongside the mill which houses not only the drive for the mill itself but also the Ilgner set and Ward Leonard motor-generator sets for the auxiliaries together with all the control gear. Fig. 5 shows a typical motor room.

The ventilation of such a house presents a difficult problem as unless electrical equipment of this category is kept scrupulously clean the reliability is impaired. One solution is to maintain a Plenum system inside the building by blowing in filtered air. This method is only fairly satisfactory since for the provision of the necessary cooling such large quantities of air have to be provided that if the filters allow even a very small quantity of dirt to pass the total weight of impurity reaching the inside of the building becomes appreciable. To reduce the throughput of air the Plenum system can be supplemented by recirculating the air through water coolers.

This principle of recirculation can be applied either to the motor room as a whole or to the individual machines but in either case electrostatic precipitators may be needed to dispose of the brush dust.

In addition to the special auxiliaries in the immediate vicinity of the rolling mill which require Ward Leonard control there are many other auxiliary drives such as roller tables for taking the metal away after it has been rolled, and for these purposes d.c. motors operated from the mains by contactors give sufficiently precise control.

All the auxiliaries associated with the mill have to withstand dirty and rough conditions, and split-framed motors in cast-steel shells similar to those used for traction purposes are generally employed. Those motors in the immediate vicinity of the rolling mill which have onerous duty cycles to perform have supplementary cooling by clean air which is piped from the motor room.

Continuous-billet mill

The slabs or blooms are fed directly into a continuous mill to produce sheet bar or billets, after which the steel is cut up for passing to the next rolling process. A continuous mill of this type comprises about six stands placed close together, driven by one motor (Fig. 6). Each stand is operated by bevel gears whose ratio is set to suit the increasing speed for the sets of rollers.

The drive for such a mill may develop 3000–5000 h.p. and may be of either the synchronous or the induction type. The motor normally runs in one direction but there may be provision for emergency stopping by plugging, i.e. reversing the supply to the motor to stop it quickly. The metal emerging from the mill is cut up as it passes through a flying shear, and complicated timing devices are required to ensure that the pieces are of uniform length.

Continuous mills for rod and narrow strip

The output from a continuous mill of the type described above is reheated and passed through another continuous mill to give products such as merchant bar and coils of either rod or narrow strip. The stands of such a mill may be arranged in a long line or in the form of a cross-country mill (Fig. 7).

Owing to the flexible nature of the product careful speed matching must be provided, and d.c. motors are used throughout. The motors are started by raising the busbar voltage, the source of direct current being either a motor-generator set or grid-controlled rectifiers; a typical rating for such an installation is 5 MW.

Marconi's Wireless Telegraph Company Ltd.

4 *Remote observation by closed-circuit television*

Fifteen monitors give the operator a composite view of 700 ft of track, the far end of which is 1000 ft away. The process is the transfer of ingots from the soaking pits to a buggy and thence by shuttle-car to the rolling mill. The electrically driven rail-cars are controlled from this dais

Light-section mills

Some of the steel from the blooming mill is cut up into equal lengths by shears and passed through a reheating furnace to a section mill which produces intermediate finished products such as light rails, angles and colliery-arch sections. Some or all of the stands of such a mill are usually of the three-high type (Fig. 8). The roller tables on each side of the mill tilt to enable the metal to be passed to and fro between the top and bottom pairs of rolls respectively.

Such a mill generally incorporates three stands. The first or roughing stand where the passes are short and

heavy is driven by a motor helped by a flywheel. The second and third (intermediate and finishing) stands operate at a relatively constant speed which has to be varied to suit different products. It is therefore usual to find this type of mill driven by d.c. motors.

Generally similar but smaller are the cross-country mills used for the production of light sections and rounds. As already described some of the output from a continuous-billet mill is reheated for supplying this type.

5 *A typical motor room*

The stands which may number up to six are mostly of the three-high type and the refinement of tilting tables may be omitted, the metal being fed into the upper and lower rolls by hand.

Continuous hot-strip mill

The arrangement of the continuous hot-strip mill is shown in Fig. 9. Slabs from the preceding slabbing mill are passed through a reheating furnace and then through a succession of roughing stands in which the metal is in only one stand at a time. The first of these is the scale breaker where the metal is given a very light draft to break up any scale. On leaving the scale breaker the metal is turned through 90° and passed through the broadside mill to widen it, after which it passes through the remaining three roughing stands.

The metal is short and thick when passing through the first two stands, and slip-ring motors with flywheels are used; but the remaining roughing stands are driven by synchronous motors. After roughing the metal is too long to pass through the stands one by one and it is fed through the six stands of the finishing mill which are mounted close together. To prevent looping or stretching careful speed matching is essential and each of the finishing stands is powered by a separate d.c. motor. The direct current for early mills of this type was invariably obtained from motor-generator sets, and the first all-rectifier design was built in South Wales.

The output from a continuous hot-strip mill is usually coiled, but with reduced draft the mill can provide sheets or plates of various thicknesses.

Traction

Little electric traction in the generally accepted sense of the term is to be found in steelworks. As on the main-line railways, steam shunting locomotives are rapidly being superseded by Diesels, mostly incorporating electric drive.

Electricity consumption

The electricity required in an integrated iron and steel works varies according to the size to which the metal is rolled. The following amounts are typical of the electricity consumption of some of the processes:

Coke ovens and by-product plant	15 kWh/ton of coke
Sinter plant	25 kWh/ton of sinter
Blast furnace	13 kWh/ton of iron
Open-hearth shop	6 kWh/ton of steel
Bessemer convertor	5 kWh/ton of steel
Cogging mills (blooms or slabs)	30 kWh/ton of steel
Continuous-billet mill	40 kWh/ton of steel
Continuous-rod mill	90 kWh/ton of steel
Hot-strip mill	120 kWh/ton of steel

To quote an example a steelworks rolling one million tons of ingots annually would create a demand of 45 MW, with an annual consumption of 250 million kWh.

Generation

Turbogenerators in a steelworks obtain their steam only after all other requirements have been met (Fig. 1). The amount of generation is insufficient for all the electric-power requirements of the works; the balance, usually much the greater part, is made up from the public supply. As conventional speed governing would encroach on the steam demand of the other works users, inlet-pressure governing is provided so that the generators absorb all the steam that is left over after the other requirements have been met.

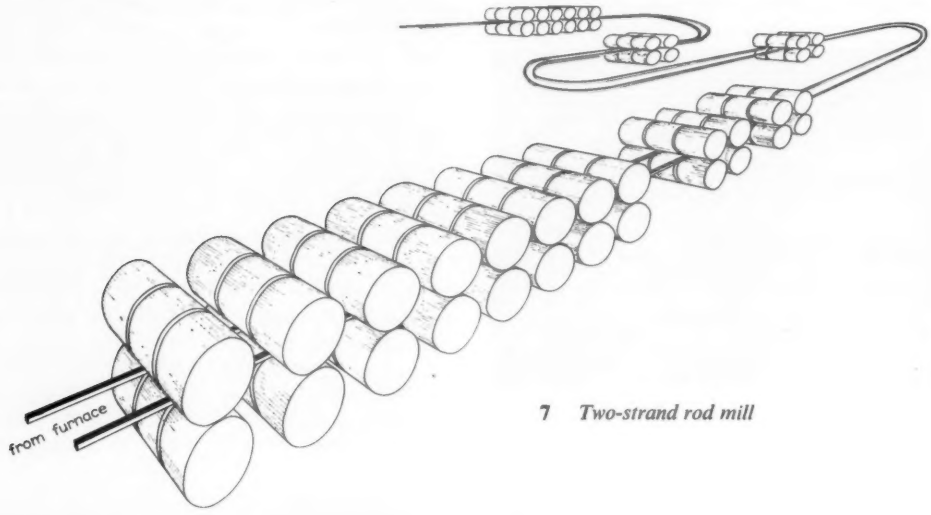
6 *Continuous mill*

Such generators operate in parallel with the public supply. So that the essential steelworks supplies such as boiler auxiliaries and pumping for furnace cooling can be maintained in the event of failure of the outside supply, special protective arrangements are provided to ensure that the generators are left carrying only that part of the load with which they can cope and at the same time the

governors change over automatically to conventional speed governing.

Steelworks power stations vary in size very considerably but an average figure for the installed generating plant is about 20 MW. While they are usually operated on the amount of steam available from the surplus waste heat, the nature of the electricity tariff influences the method of working. For instance if there is a high maximum-demand charge for purchased electricity, oil may be burnt in the boilers to increase the steam-raising and so provide additional generation at times of peak load.

The tariff also affects the way of operating the voltage regulators on the generators. If there is a severe penalty for poor power factor the generators are operated at full field and the regulator is adjusted so that it functions as little more than an overvoltage regulator in case the steelworks station falls out of parallel with the Grid.



7 *Two-strand rod mill*

Distribution

Electrical distribution in an iron and steel works is governed partly by the geography of the site and partly by the size of the motors. Up to about 200 h.p. 415 volts are used; from about 100 up to 2500 h.p. and sometimes more, 3300 volts are employed; and from about 2000 up to the largest motors encountered, of the order of 7000 h.p., 11 000 volts are used. There are thus intermediate zones where motors may be supplied at a higher or lower voltage and the decision is governed by other factors such as standardization, location, availability of transformer capacity, etc., but nearly always three distribution voltages are needed.

Although every effort is made to ensure simplicity large numbers of high-voltage circuit-breakers cannot as a rule be avoided, partly because of the quantity of motors and partly because of the need to provide standby supplies. As far as possible the supply is split up into sections so as to limit the prospective fault current; thus not only is the first cost of the switchgear kept to a minimum but so also is the damage which may be done to a motor winding if a short-circuit occurs.

One of the most important ancillary services at a steelworks is the cooling water for the various furnaces. The supply to the main pump-house, although by no means the largest, is certainly the most important from the point of view of continuity. Special arrangements are made so that should the public electricity supply fail the pump-house continues to receive electricity from the steelworks generators and vice versa.

In addition to the special Ward Leonard drives, direct current continues to play a large part in the operation of a steelworks. In most parts of the works, d.c. mains up to 500 volts supply cranes, many rolling-mill auxiliaries and a certain number of d.c. variable-speed drives such as fans. In most modern installations direct current is provided by mercury-arc rectifiers in either glass bulbs or pumpless steel tanks but the future may see a change to germanium or silicon rectifiers.

Until now 11 kV has been the highest voltage needed for most internal distribution in steelworks but with continued growth larger plants are having to turn to higher voltages such as 33 or 66 kV to strengthen their distribution systems. Comparatively little air-break or air-blast switchgear is used in steelworks for 11 kV distribution, and most of the equipment is conventional metalclad gear using oil circuit-breakers.

In older works contemporary power-station practice was followed and the switchgear was often installed on galleries; but in modern plants the switchgear is housed in conventional switch-houses with all the usual

precautions against fire, such as drainage for spilt oil carbon dioxide equipment.

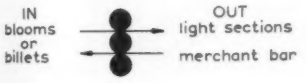
Although many oil circuit-breakers are in use on 3300 volts there is a tendency to change to air circuit-breakers. Though the latter are more expensive the switchboards can be installed in motor rooms and other similar locations without introducing a fire hazard and with lower building and cabling costs.

Similar arguments apply to 415 volt switchgear. The trend apparent in some other industries towards the replacement of substation switchgear by fusegear is not apparent in steelworks, probably because of the size of the circuits. Switch fusegear is however largely used for subdistribution outside the substations, and in fact any other kind of fuse than the h.r.c. type is practically unknown in modern steelworks.

Lighting

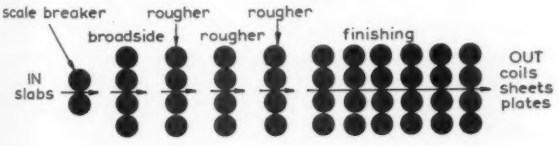
The availability of high-pressure mercury-vapour lamps up to 2500 watts has made good illumination possible without an excessive number of fittings in locations such as the casting bays of a melting shop which may be 100 ft high. It is usual however to 'mix' some gas-filled lamps with the mercury lighting. The maintenance of lighting fittings over continuously operated cranes often makes the provision of walk-ways essential.

Another problem has been the illumination of marshalling yards for rail traffic for which groups of searchlight fittings have been mounted on the top of 150 ft towers, a technique which has been followed by the railway authorities.



8 *Three-high mill*

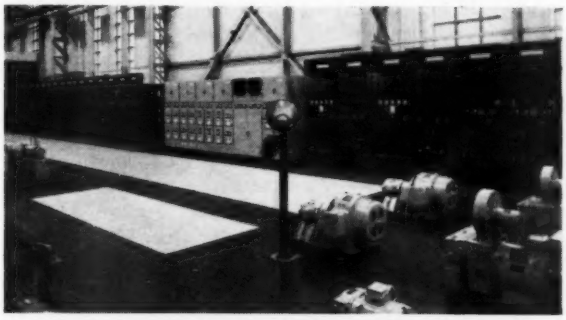
9 *Four-high continuous hot-strip mill*



Communication

In an integrated steelworks communication naturally plays an important part. In addition to communication outside by conventional Post Office telephones a works p.a.x. of several hundred lines is found in most installations. In addition for dealing with emergencies direct-wire telephone circuits sometimes working in conjunction with supervisory control systems are provided between key points on the electricity, gas and water networks.

A radio-frequency signal superimposed on power mains is used for communicating with the crane drivers on high bays, and radio links are provided for communicating with shunting locomotives for the control of railborne traffic. 'Speaker/mike' systems are used on long process lines such as rolling mills; each operator is provided with a microphone and is within earshot of a loudspeaker.



10 *Control panels for the finishing-mill stands and down-coilers at a steelworks*

Instrumentation

With the many and varied forms of fuel used in a steelworks it is easy to realize that incorrect combinations could lead to wasteful operation. For this reason, not only in the boiler plant but also in the coke ovens and other specialized furnaces, automatic control together with a comprehensive arrangement of recording instruments are taken for granted. Fig. 10 shows the electrical control panels for the finishing-mill stands and down-coilers at a steelworks.

Summary

The raw materials and the flow of production in an integrated iron and steel works are described, starting with the coke ovens, by-product plant and blast-furnace plant and passing on to the melting shop where steel is produced from iron by the open-hearth process. Electric arc furnaces are mainly confined to the production of special steels though it is reported that a British steelworks will in five years replace 21 open-hearth furnaces by six arc furnaces. The principal types of rolling mill are explained.

The salient features of the electrical equipment for working in difficult conditions are mentioned. Electricity is generated from surplus waste heat; and while some of the balance may be made up by other fuels the greater part is obtained from the public electricity supply. The range of motor horse-powers and types to be supplied calls for a three-voltage distribution system together with direct current.

The assistance of the British Iron and Steel Federation in the provision of photographs for this article is acknowledged.

Lighting and architecture

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Developments in the relation of artificial lighting to architecture could well affect the concept of lighting design and might lead to new professional relationships. In this article the author traces the developments in three stages: decorative lighting equipment which forms part of the furniture of the room, with little change from equipment designed for flame sources; lighting equipment integrated with architectural features, including false ceilings and indirect lighting; and a new method known as 'design of the visual field' in which the lighting installation is so planned as to produce a designed appearance of the whole interior.

The article is based largely on the Utilization Section Annual Lecture delivered by the author on the 7th May 1959 at Savoy Place (see August 1959 Journal, p. 488).

Mr. Waldram is with the Research Laboratories of The General Electric Co. Ltd., Wembley, Middlesex.

J. M. WALDRAM, B.SC., ASSOCIATE MEMBER

WHEN we invent a device for doing something which has already been done by less efficient means, the first stage in evolution is often merely to use it to do the old job without thinking out the problem afresh and seeking an entirely different approach which the new device might make possible.

This tendency is seen particularly well in the development of lighting in its relation to architecture: for electric lamps provided a new means of doing an old job, the history of which has affected practice and development almost to the present day.

LIGHTING EQUIPMENT AS FURNITURE

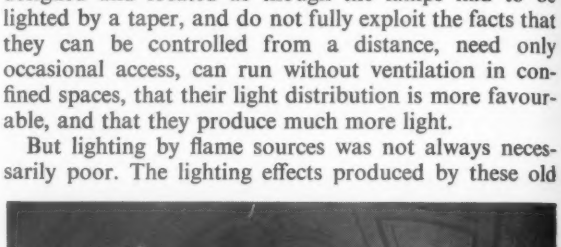
Oil lamps were not much more powerful than or different from the candles they replaced: the pattern of lighting did not change. We had portable and bracket lamps or lamps suspended from the ceiling, none fixed high, for they had to be reached and in any case their low power and poor light distribution would not have permitted high mounting. In large interiors several candles or lamps were used together in a single fitting, the candelabrum. Gas lamps were more powerful, yet they merely replaced oil, except that the portable type was ruled out since now energy was supplied by a fixed distribution system external to the lamp.

Conventional electrical fittings

Electric filament lamps are still similarly used, for we make table and floor standards and pendants and candelabra of several lamps. More important, we have until recently regarded it as established that interiors are lighted by hanging up lights within the space, usually from the ceiling and not very high, reinforcing them sometimes by brackets or adding local lights. Lighting codes and published methods of calculation assume the same practice. When a new lamp appears we are usually expected to make pendant equipment for it even when this is aesthetically almost impossible.

In such conventional equipment the flame sources have been replaced by electric lamps without taking full advantage of their superiority. Such fittings are still designed and located as though the lamps had to be lighted by a taper, and do not fully exploit the facts that they can be controlled from a distance, need only occasional access, can run without ventilation in confined spaces, that their light distribution is more favourable, and that they produce much more light.

But lighting by flame sources was not always necessarily poor. The lighting effects produced by these old



1 *Pendant lighting equipment in the Clothworkers' Hall, London*

lamps have a special charm which electricity cannot match; many paintings bear witness to the beautiful effects of light and shade, emphasis and modelling sometimes produced by a local light, which are lost when the shadows are drowned by light which invades every corner.

Candlesticks and oil lamps were made by artist craftsmen and furniture makers, and some were very fine; the traditional designs have rightly persisted. There is a considerable industry today concerned in making decorative lighting equipment, some in 'period' styles and some a little uncertainly called 'contemporary', using both old and new materials and finished often with great skill.

The increasing attention given today to artistic design, sponsored by the Council for Industrial Design and the Design Centre, is having a good effect on the external appearance of lighting equipment produced in quantity as cheaply as possible. For important interiors equipment is often designed by the architect.

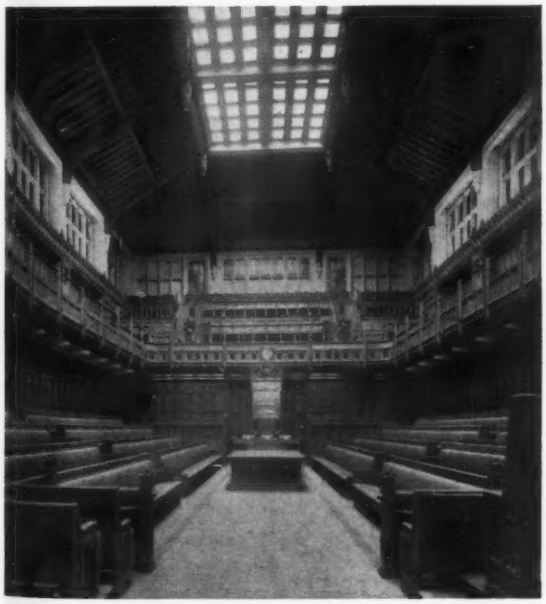
Lighting equipment of this kind, called 'decorative', is part of the furniture of the interior rather than of its architecture. It is not applied ornament and it is not integrated with the structure. Such equipment can make a real and important contribution to the decoration of some interiors and to the furnishing of the space, and this function must never be forgotten (Fig. 1).

But we are no longer bound to the old conventions and recognize that there are other functions of lighting to consider, aesthetic as well as practical; that not every kind of architectural space calls for that kind of furniture; that new lamps give new opportunities to the architect not merely to furnish his space but to integrate the equipment in his design; and finally that light, not merely lighting equipment, is an integral part of architecture.

LIGHTING EQUIPMENT AS AN ARCHITECTURAL ELEMENT

Although at first electric lamps replacing earlier sources did not exploit their own advantages, before long new techniques were introduced which did. Indirect lighting originated with the arc lamp: with this system the ceiling, an important architectural feature, was made unusually bright and became an integral element of the lighting system although its form was generally lost. The system was also used with filament lamps, often in a cornice lighting the ceiling only and themselves completely hidden by day and night.

This quite abandons the notion of lighting equipment as furniture and makes no inroads on the space. However the efficiency is very low; and the visual effect when indirect lighting is used alone is unfortunate, since the over-bright ceiling claims the attention but is itself poorly revealed, and the objects of regard seem dim.



2 *Lighting from a built-in laylight in the Chamber of the House of Commons*
Concealed lighting is also provided for the upper walls and roof, and under the gallery

3 *Suspended luminous ceiling using plastic diffusers*
The space above such a ceiling is available for services

During the 1930's a fashion arose dignified by the name, perhaps ill-deserved, of 'architectural lighting'. This meant that some feature of the room was made luminous, such as the architrave of a door, the proscenium of a theatre, a column or a beam, for example by forming on these features boxes glazed with heavy moulded glass containing lamps.

The aim was primarily for decoration: but the effects produced were usually rather crude; the features treated were emphasized quite disproportionately to their architectural purpose and made to appear swollen and ugly. Structural elements such as beams and columns which not only provide but imply the strength of the building became unsubstantial and weak.

Luminous ceilings

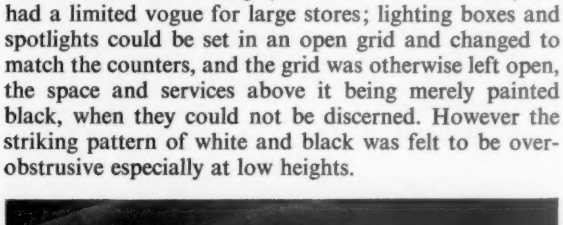
A better development of the same idea is found in the luminous ceiling, false ceiling or laylight, as in the Lecture Theatre of The Institution; the principle was carried to great elaboration in the Chamber of the House of Commons by Sir G. Gilbert Scott (Fig. 2). The Royal Festival Hall has an illuminated ceiling formed as a series of coves gently lighted by cold-cathode tubing; the reflected light is reinforced by inconspicuous spotlights directed downwards, providing both extra light and modelling, so avoiding the characteristic defects of indirect lighting. The concert platform is made the principal object of regard by powerful down-lights.

False or suspended ceilings (Fig. 3) have recently become popular because they provide at once a concealment for the elaborate services now demanded, a neat method of lighting, and a means for acoustic treatment

and, in a recent development, for heating as well, using panels heated by hot water or electrically.

An over-all transilluminated diffusing ceiling is however optically identical to an indirect system and shares its defects, though at the higher levels of brightness possible the sense of dullness is less marked. However, instead of using the complete ceiling, only a part may be employed for lighting, or lighting fittings may be recessed in the suspended ceiling, individually or in continuous rows or 'troffers'.

The 'Rotterdam ceiling' (first used in a store there) has had a limited vogue for large stores; lighting boxes and spotlights could be set in an open grid and changed to match the counters, and the grid was otherwise left open, the space and services above it being merely painted black, when they could not be discerned. However the striking pattern of white and black was felt to be over-obstrusive especially at low heights.



4 *Drawing office lighted by reflector troughs forming louvres*
The troughs also provide heating and acoustic treatment

Use of louvres

The 'egg-crate' louvre is perhaps the only new device for light control to appear in recent years. Its elements are white, translucent or of matted metal, used to control diffused light; if the absorption at their surfaces is low the louvres are reasonably efficient and permit the realization of a high illumination on the working plane without the ceiling or lighting fitting being too bright at usual directions of view. Such louvres may be used either on lighting fittings or covering the whole or a large part of the ceilings: the latter application poses some nice problems of construction.

Louvres are used in many ways for control and decoration. Drawing offices have been lighted using cross-louvres only, formed with the structure, with cold-cathode lamps; in a refinement of this idea in one office (Fig. 4) where all the draughtsmen face in one direction the ceiling is formed with metal troughs of designed contour each containing a cold-cathode tube.

The troughs have a slightly matt surface so that the reflectors are not flashed at normal directions of view and their brightness is quite low, but they provide high illumination of the boards over a wide angle, so that sharp shadows do not occur, and there is a heavy cut-off to the lamps themselves.

This system gives a high illumination with perhaps the lowest ceiling brightness normally possible. Furthermore the ceiling is also the source of heat, for the troughs are heated by a hot-water system and they are perforated to provide sound absorption in conjunction with the heat-insulating blanket above them. The ceiling thus deals with heat, light and sound; but the use for heating sets problems for the fittings maker.

The principle of 'architectural lighting' comes full circle when the architect designs a suspended ceiling as a decorative feature, usually covering a part of the interior only, and houses in it down-lights, illuminated features or equipment to light the structural ceiling above. Here light is being used as an element in decoration, not in the form of lighting equipment as such but in units designed with the interior which incorporate lighting equipment or lighted motifs. Possibilities of such design are endless (Fig. 5).

Artificial light and daylight

Some of the examples of ceilings just quoted point to another very important aspect of artificial lighting and architecture. Buildings are expensive; one of the problems of the architect is to provide as much rentable area as he can on the site within the cost imposed. His design is however very largely restricted by the need to provide working daylight to the interior. Contrary to popular ideas, daylight is in strictly limited supply and is very expensive to collect. The provision of working daylight profoundly affects town planning, limits the design, the economy and the permitted height of buildings and also affects the cost of heating them because windows allow heat to escape.

The economics of artificial light has however changed fantastically in recent years with the coming of new lamps and cheap energy. The true running cost of artificial light in lamps and energy is now about one-sixtieth of what it was 30 years ago. Today artificial light is cheap and daylight is expensive, and it is time to review their relative positions as they affect building and town planning. It is not of course suggested that we should build windowless buildings, which are abhorrent to most people, or streets like canyons. What we like about daylight is not merely the working light but the view and the contact with the outside world.

The daylight we can get is valuable, but it is no longer necessary to hamstring designs in the attempt to provide working daylight everywhere. Good artificial light allows the full use of every room, as central heating permits the full use of every part of a building and not merely the zone near the fireplace; its intelligent use by day is an economy not a waste when the whole economic picture is considered.

But we must not be dominated by economy; if we are to live under more artificial light we need to consider carefully the effects which it produces from the aesthetic as well as from the economic point of view.

DESIGN OF THE VISUAL FIELD

We have traced the contribution of lighting equipment to the furniture of the room and its use in association with the architectural features of the room. In both respects lighting has much to contribute; nevertheless it is apparent that various devices have been tried without any clear aim; and there have been increasing complication, both in lamps and circuits and in illuminating engineering, and inflated demands for high levels.

Yet no use is made in practice of much of the available work, nor is account taken of one of the most fundamental properties of the eye, known for years, of adapting its sensitivity to the brightness of the scene presented to it, like an automatic volume control; nor of the fact also clear for many years that the *relative* distribution of luminance in a room is at least as important as, often more important than, the mean absolute illumination.

The situation clearly calls for rethinking; and in the last few years a new approach to problems of interior lighting has been worked out in this country which shows promise of rationalizing these problems, both architectural and technical. In 1954 a sub-committee of the National Illumination Committee of Great Britain issued a report entitled 'The design of the visual field' which reviewed the situation and which stimulated other work in this country, resulting in quite new methods of design.

The title implied 'the architecture, furniture, decoration, colour and light compounded together into an aesthetically satisfying whole'. At that time the possibility of so compounding them had still to be worked out, but it was recognized that they would have to be compounded deliberately by an artist-engineer in any final solution; since then methods have been devised.

5 *Luminous ceiling elements forming part of architectural design at Lloyd's, London*

Interplay of forms and light

Some years previously I had pleaded for lighting which went beyond engineering, and pointed out that architecture resides in the significant interplay of the forms provided by the architect and the light provided by the lighting artist. For architecture is a visual art; there is no architecture in the dark. Light is of the very stuff of architecture—light, not just lighting equipment. It is not what the equipment looks like, by day or even by night, but what the interior looks like when it is lighted. The architect may design and locate fittings which embellish the interior only to find that at night its whole aspect is ruined by the lighting which they provide.

The new method of interior-lighting design begins with a conception of the appearance of the lighted interior, perhaps as sketches. Means have been found of interpreting the architect's aesthetic conception in numbers, particularly with reference to the distribution and level of brightness and the emphasis, the decoration, and the modelling. (Illumination is considered mainly as a means to achieving brightness but also in its own right.)

The adaptation effects can then be estimated and allowed for and reflection factors of the various surfaces taken into account in detail; interreflection can be estimated very simply—this was an unexpected bonus—and finally the direct light can be found which must be provided by the lighting installation on each of the principal surfaces. The directions from which light should come, hence the sites for the equipment, are indicated by considerations of modelling.

The design of the installation to produce these direct illuminations proceeds from this point. The decision whether to use decorative equipment or luminous features forms part of the original concept; it may be that concealed equipment is needed for modelling or emphasis. When the equipment has been decided it is simple by this procedure to check for glare by any proven formula.

Rationalization of design processes

This brief outline indicates that the new approach which has been called 'designed-appearance lighting' goes far to rationalize the processes of interior-lighting design:

It commences with a conception of the finished appearance of the lighted interior
It establishes the proper contribution of the architect and separates it from that of the lighting engineer
It takes adaptation into account for the first time
It allows in detail for reflection factors of surfaces and indicates what they should be and how they can contribute to the final result
It includes design for emphasis and modelling
It greatly simplifies the estimation of interreflection
It permits and simplifies the estimation of glare.

Of these the first step is the most important because by beginning in this way the designer has specified what he

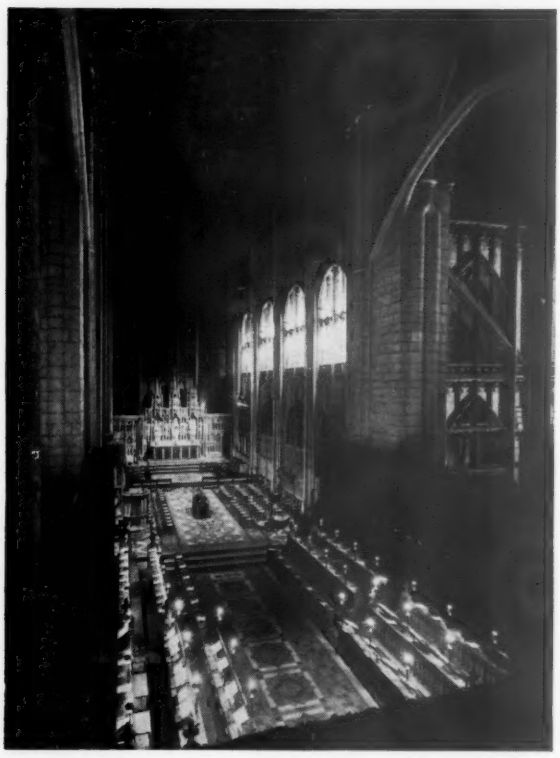
wants to do, with some precision and for that interior; once this is laid down the engineer can usually find means to realize it, invoking the detailed procedure only so far as it is justified. If the designer specifies his wants properly, requirements of codes are met automatically. He is led to a rational relationship between appearance and decoration.

It is especially satisfying that once the aesthetic aim has been stated the lighting engineer has a definite target and can use every available device to attain it; he can be much more of an engineer than before, when the aim was so vague that detailed work was pointless. Now there is much more that he can do and it is well worth while.

Functions of engineer and architect

In theory at least the conception of the appearance of the finished and lighted interior is a task for the architect and defines his proper part and that of the lighting engineer; and here the situation is exactly parallel with that in other engineering services for a building.

An engineer is a man of measurement, and he measures and sets limits which he expresses in codes the function of which is to ensure that the building is safe and habitable; the architect's task is to design a building suitable for its job, within the limits of cost, and architecturally memorable. By drawings and specifications he transmits his design back to the engineer who erects it.



6 *Designed-appearance lighting at Gloucester Cathedral*

Calculated effects include emphasis of the High Altar and modelling of the High Altar, vault, pulpit, north wall and organ (not visible here), and choir stalls. There are eight distinct lighting systems in this space

Lighting can now take its place in a similar mechanism. The engineer's code provides not the aims but the limits within which the architect designs (although, as has been remarked, lighting is more intimately related to the architecture than any other service, and the architectural and technical aspects cannot be separated clearly enough for independent handling). By the new techniques the design can then be transmitted to the lighting engineer, who designs the installation to realize it.

This approach to interior lighting is naturally most useful in large and complex interiors; but it has been simplified for application to a rectangular enclosure and the arithmetic reduced to a work-sheet. However, we have not yet reached the point at which everyday interior lighting can be designed by this method as a routine, for different lay-outs and possibly new kinds of equipment and new catalogues are needed before the designer can choose standard equipment as called for by the design.

Nevertheless we may have pioneered a route through terrain hitherto impassable; and although it will be some time before the route becomes a motorway it is now possible to get traffic along a useful length of it and we are in a position to align the rest.

Gloucester Cathedral

The method is valuable in a new building since the lighting can be predicted with some confidence before the building is up, and costly and inconclusive experiment can be avoided. However it is also helpful in an old building because reliable estimates of wiring can be made at an early stage. The most interesting application of the technique so far made has been to a very old building, Gloucester Cathedral (Fig. 6).

This was a case of unusual complexity, in that it involved a number of vistas from one space into another and that the uses of various parts of the building were very varied. The appearance of each main space was laid down and a calculation made as here outlined; the lighting installation was designed and specified in detail by calculation, giving the sites, equipment, lamps and orientations. Very few changes were needed from the planned installation. The advantages of this to the electrical engineer in the orderly planning and costing of the job are obvious.

New approach to training

This method of lighting design opens new possibilities and poses professional problems, one of which may be a closer liaison between architects and lighting engineers, hitherto hindered by the very different approaches of the two professions. It is bound up with the training of the lighting engineer. Ten years ago in a Presidential Address to the Illuminating Engineering Society I pleaded for the training of lighting artists skilled in both

engineering and aesthetics; and experience has confirmed the need.

Although it is now possible to distinguish the functions of the architect and the engineer, it has become clear that good lighting of fine buildings will not come about merely by their collaboration. Often one is faced by a compromise between technical and aesthetic requirements, a good solution to which can only be reached by one man who can fairly balance the two, understanding both.

This is a matter for training, and I hope that, as the possibilities develop and it is demonstrated that there is a worth-while job in lighting along architectural lines, more men will choose it as a profession and that the two professional bodies concerned will combine to train them.

Summary

Lighting equipment as an element in decoration has an important part to play in suitable interiors. Such equipment remains traditional, being based on flame sources of low power which must be accessible, and is generally hung within the space to be lighted. However, modern lamps permit other approaches, and many interiors are not best treated by suspended equipment.

Lighting which is integrated in the architectural treatment can take account of the possibilities of electric lamps. Indirect lighting and its modern equivalent, the suspended luminous ceiling, are apt to give a false and flat effect; but this can be overcome by several devices. Suspended ceilings are convenient for concealing the many services now required. Luminous devices designed by the architect as part of the interior avoid the crudities of the early 'architectural lighting'.

The latest trend reverses the conventional approach by considering first the appearance which the whole lighted interior should have, translating it into figures, taking account of effects of adaptation (hitherto neglected), allowing for reflection factors, and including design for modelling and emphasis. This procedure leads to a new conception of lighting design, which may lead to new liaison with the architectural profession.

GRAHAM CLARK LECTURE

THE sixth Graham Clark Lecture will be given by Sir Hugh Beaver, K.B.E., M.I.C.E., M.I.CHEM.E., M.E.I.C., on Thursday, 3rd March 1960 at Savoy Place. His subject will be 'The engineer and civilization'. This will be a joint meeting with The Institutions of Civil and of Mechanical Engineers and will begin at 5.30 p.m.

Sir Hugh became assistant to Sir Alexander Gibb in 1922. At the request of R. B. Bennett, then Prime Minister of Canada, he directed the rebuilding of the harbour of Saint John, New Brunswick, after its destruction by fire in June 1931. He became a partner in Sir Alexander Gibb and Partners in the same year and was concerned in the measures for the reindustrialization of the depressed areas of South Wales, Tyneside and Durham, and West Cumberland. During the Second World War he was Director-General in the Ministry of Works and was responsible for the planning and control of the building and construction industry.

Sir Hugh Beaver

He joined Arthur Guinness, Son and Co. in 1945 and became managing director in 1946.

He was from 1954 to 1956 Chairman of the Advisory Council of the D.S.I.R. and of the Committee on Air Pollution in 1953–54; and President of the Federation of British Industries and of the Institution of Chemical Engineers from 1957 to 1959. In 1957 he became Chairman of the British Association's Committee of Enquiry into the Metric System.

Sir Hugh is an Honorary Doctor of Law of Cambridge University and of Trinity College, Dublin, and an Honorary Doctor of Economic Science of the National University of Ireland.

Panel on Adequate Wiring

THE constitution of the Panel on Adequate Wiring for Electrical Installations in Buildings, set up in April 1959 by the Council of The Institution on the recommendation of the Utilization Section, is as follows:

Mr. J. I. Bernard, B.SC.TECH., M.I.E.E. (Chairman)
Mr. J. R. Beard, C.B.E., M.SC., HON.M.I.E.E.
Mr. J. Flood, ASSOCIATE I.E.E.
Mr. Forbes Jackson, M.I.E.E.
Mr. R. A. Marryat, B.SC.(ENG.), M.I.E.E.
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Mr. R. F. Richardson, M.B.E., M.I.E.E.
Mr. E. G. Cole, A.R.I.B.A. (nominated by the Royal Institute of British Architects)
Miss M. George, M.B.E. (nominated by the Electrical Association for Women)
Mr. D. L. Tabraham, F.I.E.S. (nominated by the Illuminating Engineering Society)

The terms of reference of the Panel are:

'To formulate and publish recommendations of good practice for the adequacy of fixed electrical installations in buildings and to consider the dissemination of such recommendations in order to enable architects, builders, local authorities and others to acquire an informed view in this matter'.

THE DEVELOPMENT OF EUROVISION

621.397.13

Interesting problems have confronted communication engineers in the development of the interchange of live television programmes between the countries of Western Europe. In this article, which is based on his Chairman's Address given to the Electronics and Communications Section at Savoy Place on the 28th October 1959 (January 1960 Journal, p. 63), the author traces the growth of Eurovision from its earliest beginnings in 1952 to the present time. Mr. Pulling is with the British Broadcasting Corporation.

M. J. L. PULLING, C.B.E., M.A., MEMBER

EUROVISION is the name which has been given to the interchange of live television programmes between European countries. The rapid development of these exchanges has presented the communication engineer with some interesting technical problems. But perhaps even more important has been the challenge to his ability to improvise and to co-operate on the international plane.

In June 1959 the B.B.C. and 12 other European television organizations celebrated the fifth anniversary of a big and decisive step forward in programme exchanges between European countries. But the exchanges of June 1954 were not in fact by any means the first that had taken place. There had been some on a restricted scale in both 1952 and 1953 and it might be said that thoughts along these lines had started to crystallize as early as the latter part of 1950.

First television broadcasts from Europe

In August of that year the B.B.C. carried out two television outside broadcasts from Calais by way of celebrating the centenary of the laying of the first cross-Channel telegraph cable. This was the first occasion on which television had been brought to the British public from a point outside the United Kingdom and the first time that a television link had been set up across an international boundary.

The programmes were seen only in the United Kingdom however and not in France. There were two reasons for this. One was that France had not as yet started to develop its television network—its only transmitters were in Paris—and to link Calais to Paris as well as to London would at that time have been beyond the joint resources of the French broadcasting authority, Radiodiffusion Télévision Française (R.T.F.) and the B.B.C. The second and more cogent reason was that the French and British television services were operating as they still are on different line standards and there was in 1950 no known means of converting the vision signals from one standard to the other.

These outside broadcasts were on several counts the most ambitious the B.B.C. had undertaken. They involved the sending of a large outside-broadcast team with all its equipment over to Calais and the setting up of a series of point-to-point radio links between Calais and London. The Channel was spanned by a link working between the Hôtel de Ville at Calais and a mast on the top of the cliffs at Swingate near Dover. The span from Swingate to London required three further links.

The results if not spectacular were at least encouraging and were acclaimed by the English Press and viewing public. The chief technical problems had of course been those concerned with the transmission of the vision signal from Calais to London with such transportable transmitters and receivers as were available at that time. Very little experience then existed as to the cumulative effects of various types of distortion when a number of such radio links were connected in tandem.

Shortly after this R.T.F. and the B.B.C. discussed the possibility of a week of outside broadcasts from Paris to be carried out in July 1951 but the project did not materialize.

A week of joint programmes

Meantime serious thought was being given both in France by R.T.F. and in the United Kingdom by the B.B.C. to possible means of conversion from the French line standard of 819 to the British of 405 and vice versa. In both countries the same general method was being

1 *Cassel–Swingate television relay-link aerials on the roof of the Casino at Cassel: July 1952*

pursued. By February 1952 it was considered that the results which were being obtained both in Paris and in London were good enough to justify plans being made for a series of joint R.T.F./B.B.C. programmes in July of the same year.

These were to be produced in Paris using French cameras and equipment and broadcast simultaneously by the French and British television services, thus becoming the first television programmes to be broadcast simultaneously in two European countries.

By this time R.T.F. had opened at Lille its first 819-line regional television station and this was fed by a permanent circuit from Paris. The problem of linking Paris to London was thus reduced to one of linking Lille to London. R.T.F. undertook the responsibility for a link from Lille to Cassel, a very convenient high point on the way to Calais (see Fig. 1), and at Cassel the B.B.C. standards convertor was installed. The conveyance of the 405-line signal from this point onwards to London was the B.B.C.'s responsibility, the route chosen being Alembon–Swingate–Wrotham–London, a route mileage of about 130.

The programmes were spread over the week 8th–14th July. The technical quality of the pictures broadcast in Britain was distinctly variable. At their best the pictures were entirely acceptable, but at their worst they were marred by every imperfection known to the television engineer. None the less, confidence was felt on both sides of the Channel that these imperfections were not fundamental and could be overcome by technical improvements which it was fairly obvious could be achieved.

Relaying the Coronation broadcast

In December 1952 a meeting was held in London to discuss the practicability of relaying the television broadcast of the Coronation of Queen Elizabeth, not only by the French television service but also by those of the Netherlands and the German Federal Republic in both of which countries television services had started, working on a standard of 625 lines. No service existed at this period in Belgium and much therefore depended on whether the Netherlands Television Service, with help from the Belgian authorities, could convey the signals from Cassel or Lille to the Netherlands stations at Lopik and Eindhoven, whence they could be passed to Cologne, the nearest point on the German network.

As a result of strenuous efforts by all concerned the requisite circuits were established and on Coronation Day, 2nd June 1953, the B.B.C. broadcast was relayed by a total of 12 transmitters in France, the Netherlands and Western Germany, the extreme point on the network being Berlin.

There is no doubt that this broadcast aroused great interest in the countries concerned and elsewhere. On the technical side much had been learned and it was already becoming obvious that problems associated with sound and communication circuits were likely to present considerable difficulties in the future. It was clear too that

2 *The television-exchange network in June 1954*

Radio Times

these problems were going to require the closest co-operation with the P.T.T. administration since many of the requirements in regard to sound circuits were novel and were not clearly legislated for in existing C.C.I.F. recommendations relating to sound broadcasting.

At this point in time, great impetus was given to the development of international relays by the starting of television services in Switzerland, Belgium, Italy and Denmark. Plans were accordingly laid for a much more ambitious series of daily programme interchanges, involving this time eight national television organizations, to be carried out in the month starting on the 6th June 1954. The general plan was that during this period each of the countries should contribute one or more programmes, each of which was to be relayed by all the others.

Need for co-ordination centre

It was very soon realized that it would be necessary to establish at some point on the network a co-ordinating centre with direct telephone connections to the technical and programme headquarters of each of the participating services. This International Co-ordination Centre was set up by R.T.F. in part of an area in the Town Hall at Lille occupied by the French television service. Lille was convenient as it was possible there to monitor the video signals of each of the three line-standards: 819 the local standard, 405 arriving from London, and 625 from Belgium, the Netherlands and beyond.

On the technical side we were accepting considerable risks. The route mileages between extreme points on the network, such as Rome and Copenhagen, were of the order of 1200 (see Fig. 2). Taking this route as an example, it consisted entirely of radio circuits and involved equipment provided by five different authorities. The total number of individual links connected in tandem was 27 and the video signal was modulated and demodulated at least a dozen times between one terminal and the other.

In the circumstances, and bearing in mind that many of the links were entirely temporary and provisional in character, it was to be expected that the resultant distortion of the picture would be severe. But how severe? The answer could not be obtained mathematically and even if it could it would be impracticable in most cases to say how serious would be the subjective effect on the viewer of the degree of distortion indicated by the calculation. The only possible way to find out the answers was to set up the circuits and try them out.

Tests of the whole network were carried out in April 1954 and showed up a number of weaknesses. However to the surprise of many the picture quality obtained was, even over the longest links, considered to be acceptable having regard to the novelty value of the whole project.

In the few weeks which were available, certain improvements were made and the final practical details of the programme exchanges took shape. The series started with a memorable broadcast on the 6th June by His Holiness the Pope and continued until the 4th July. The month's exchanges were from the technical point of view if not a triumph at least a modest success. Mistakes had been plentiful but much had been learned. When they were over, many of the temporary links had to be dismantled and the equipment returned to its rightful owners or to its normal use.

A more permanent basis

It was clear that Eurovision, as it had now come to be known, was here to stay. The next consideration was how it should be kept going on a permanent basis. Up to this time it had been controlled by a series of *ad hoc* international meetings on both programme and technical sides. These had had to concern themselves with the minutiae of each and every broadcast. Clearly this arrangement could not continue indefinitely.

By now however eight television organizations, all members of the European Broadcasting Union, were taking part and the logical step was therefore that the E.B.U. should take over the responsibility for planning and supervising these interchanges on a routine basis. The Administrative Council of the Union approved this proposal and set up three working parties, one of them reporting to the Programme Committee of the Union and two to the Technical Committee.

The E.B.U. has two headquarters, the administrative being located at Geneva and the technical at Brussels. Geneva was to be responsible for the organization of programme aspects of the exchanges and Brussels for the technical planning as well as for supervision while the exchanges were in progress.

For this latter purpose a co-ordination centre was needed to replace the temporary one at Lille and this was established in the Palais de Justice in Brussels. This, being the focal point of television links to and from France, Germany and the Netherlands, was about as favourable a spot as could have been hoped for. The equipping of two rooms, intended respectively for technical and programme co-ordination, was carried out in the latter part of 1955 and the centre came into operation in January 1956.

Its functions at that time were purely passive, i.e. the technical staff would be in touch with the control room of each of the organizations taking part in a relay, by means of control circuits set up for the purpose, in order to handle any queries. At the same time they would be able to monitor the pictures, provided of course that they were passing through Brussels which would very frequently be the case.

The centre has gradually come to assume a more active role, particularly when handling complex programmes, and it can now fulfil a function in relation to the whole European network similar to that of each national control centre in regard to its national network.

There are of course numbers of exchanges of the most straightforward kind between two neighbouring countries which require no intervention by Brussels, but it has been found in practice to be necessary for the *Control* Centre, as it has now become, to take charge of every relay in which three or more services are taking part.

The vision links

I turn now to the vision links themselves—the individual links which when connected up in various ways make it possible to distribute television programmes all over Europe. The very earliest links used by R.T.F. and the B.B.C. were simply low-power portable transmitters and receivers which had been taken from the routine of their normal daily existence and installed in a semipermanent fashion at the top of a water tower or on a flimsy tubular steel structure, with the control gear in a van on the ground below. Quite naturally their performance was not perfect and there were breaks in transmission. But this was the type of equipment which had to be used for international links in the early stages.

Soon however, with the availability of equipments using both decimetric and centimetric waves designed for fixed installations, the international links began to be as reliable and to possess the same general characteristics as the national links. Whereas at first at intermediate points in a chain of stations over a given route the video signal would be derived from the receiver and passed to the modulator stage of the transmitter covering the next hop, we now find that at most intermediate stations the combination of incoming receiver and outgoing transmitter is little more than a radio-frequency changer, with very much less inherent distortion of the video signal.

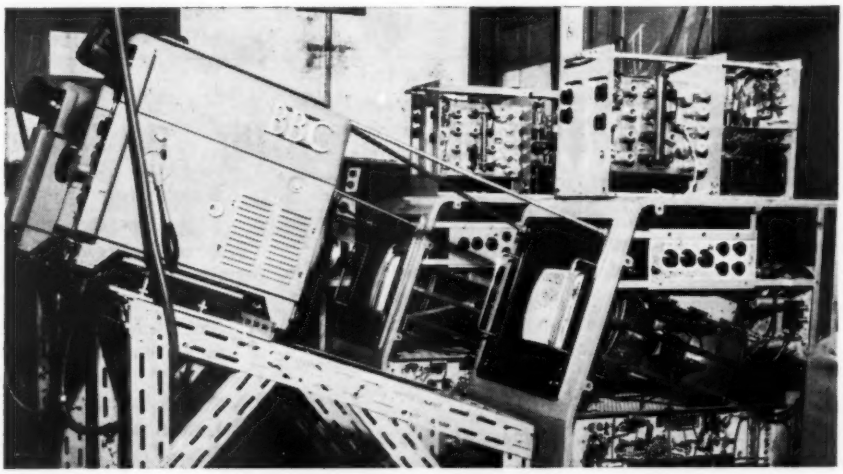
Much thought and effort have been devoted to defining

the various types of distortion to which a video signal is liable in its passage over long circuits, setting limits to them and settling methods of measurement which all the various broadcasting services and P.T.T. administrations would be prepared to adopt. In these respects the E.B.U. Technical Committee has worked in close harmony with the C.C.I.R. and C.C.I.T.T. This has led to the adoption of certain test signals which are considered to be necessary and sufficient for the assessment of the performance of long circuits. The E.B.U. technical working parties have always included P.T.T. engineers from many countries as members and full partners in this work.

The spreading network

The vision network now covers 14 countries of Western Europe, the most recent to be linked up being Norway and Finland. Television services are operating in Spain and Portugal, but no link exists as yet between them or between France and Spain.

A few sporadic exchanges have taken place with countries of Eastern Europe and a network is gradually being developed between Poland, Eastern Germany, Czechoslovakia, Hungary and the Soviet Union. It seems clear that permanent links between Western and Eastern Europe might in future be set up by way of Finland, Berlin, Austria or Jugoslavia. No additional standards-conversion problem would be introduced since the Eastern European countries have adopted a 625-line standard.



3 *The display tubes and cameras of the standards-conversion equipment installed at Cassel in July 1952*

Conversion of line standards

I have mentioned very briefly the problem of standards conversion, that is to say the problem which arises because there exist in Western Europe three basically different video-signal standards. At present the only method of converting a picture signal from one to another involves the display of the incoming picture as perfectly as possible on a picture tube whose phosphor has a long decay time (see Fig. 3). This tube is then viewed by a camera working on the outgoing standard. Clearly such a method as this must introduce some distortion. This does indeed happen despite many improvements which have been made.

We are badly in need of some more sophisticated method of transcribing from one line-standard to another. There has been considerable speculation as to whether it might be possible to develop a tube in which the incoming signal was inscribed on a suitable target and stored for a fraction of a second, when the information would be read off by an electron beam scanning it at the line frequency of the outgoing signal. It seems conceivable that if such a method could be developed it would be an improvement on the present one: at least it would eliminate some of the distortion inherent in the optical transfer process.

We have seen over and over again in recent years that electronic solutions of television problems are superior to mechanical and optical solutions and it may prove that this is also true in the present case.

No doubt a link with North America will be established one day. There has been a great deal of talk about this possibility over a very long period. From a purely technical point of view there are two or three possible solutions of the problem none of which appears unduly difficult, but what *is* difficult to see is how the fabulous cost could possibly be justified. This situation is likely to continue so long as a satisfactory television picture requires as large a bandwidth as is used for conventional systems.

Once a method existed whereby a satisfactory picture could be obtained with a very substantially narrower band of frequencies, a transatlantic circuit could become technically simple and economically feasible. Meanwhile a technique has been devised for using the transatlantic telephone cable for the low-speed transmission of 16mm film for television purposes, but this is of course quite a different matter from live television. This new technique was described at an Ordinary Meeting at Savoy Place on the 3rd December 1959.

Technical developments over the past five years can be said to have brought us to a point where television programmes can be shared by countries in Western

Europe as far apart as Sweden and Italy with a fair degree of ease and with a reasonable expectation of acceptable picture and sound quality. None the less we still have some way to go in improving both quality and reliability of both picture and sound and it can confidently be expected that these improvements will be realized before long.

Just as a decade or less ago no communication engineer would have accurately forecast the technical means which enable us to share television programmes over the length and breadth of Western Europe today, so ten years hence we shall no doubt be taking for granted a world-wide interchange by means which at present are only faintly perceived.

Summary

Starting from simple beginnings in 1952, when television existed only in France and Great Britain, the exchange of television programmes between European countries has developed rapidly, following in the wake of the establishment of television services in Western Europe. An international vision network now covers nearly the whole of Western Europe and is regularly used for programme exchanges of many kinds.

Report of Council meeting on the 7th January 1960

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 7th January 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting as some items must necessarily be regarded as *sub judice*.

Honours conferred on members

The Council noted with pleasure that Her Majesty The Queen had been pleased to confer honours on several members of The Institution in the New Year's Honours List (see p. 128).

Membership

Taking into account elections up to the 1st January 1960, it was recorded that the total membership at that date was 45233, the total at the 1st January 1959 having been 43995.

Retired Companions

In view of the special nature of Companion membership of The Institution, the Council approved a recommendation from the Finance Committee that the minimum period of membership of Companions, before qualifying for relief of payment of subscriptions, should be reduced from 25 to ten years' continuous membership and that the Committee should be given discretion to remit subscriptions before the age of 70 years, which has been the limit hitherto, when retirement occurs before that time.

Annual Accounts

The Council also approved a proposal from the Finance Committee in connection with the revision of the form in which the Annual Accounts usually appear. The Committee proposed to draw up the 1959 Annual Accounts so as to show the cost of each of the principal services provided by The Institution and to support these with an explanatory memorandum containing some graphical representation of the apportionment of funds to various services.

Building reconstruction—overdraft facilities

In order to meet the bank's requirements relating to securities for overdraft facilities needed to finance the rebuilding scheme, the Council passed two resolutions, one charging The Institution's Sinking Fund policies to the bank as agreed and another recognizing that The Institution's lease of the Savoy Place premises might have to be charged at a later date if the bank needed additional security.

Committee appointments

Appointments and nominations to Institution committees and those of outside bodies, as recommended by the General Purposes Committee, were approved. (Details appear in 'Announcements to members' in the *Journal* from time to time.)

National Certificate fees in Scotland

A recommendation from the Examinations Committee was approved accepting a revised scale of fees payable in Scotland in respect of National Certificates, as proposed by the Scottish Education Department. This recommendation had received the support of the Finance Committee. It was recalled that in December 1958 the Council had approved a corresponding revision of charges in respect of National Certificate courses in England and Wales.

Christmas Holiday Lecture

Mr. O. W. Humphreys, Chairman of the Papers Committee, introduced his Committee's report on the recent deliveries of the Christmas Holiday Lecture on 'Colour television' by Mr. G. G. Gouriet on the 30th and 31st December 1959 (see p. 136). The Council adopted this report which showed that the Lecture had proved extremely popular—so much so that Mr. Gouriet had given three deliveries instead of the normal two. The total attendance had been 1369.

Page Prize

It has hitherto been the practice of the Examinations Committee to withdraw the name of the Page Prize winner from the list of Institution Prize winners, the qualification

for both prizes being somewhat similar. It is now felt by the Examinations Committee that this arrangement tends to debase the value of the Page Prize and they recommended that the winner of the Page Prize should in future not be debarred from receiving the award of an Institution Prize. The Council agreed to this proposal.

Institution Prizes

The Council also approved the recommendations of the Examinations Committee for the award of Institution Prizes in National Certificate Session 1959 and authorized the sending of a letter conveying congratulations to 23 students who did not qualify for the award of an Institution Prize solely because they were over 26 years old on entry to the final year of the course. The necessity to continue to apply this age limit was raised and referred to the Examinations Committee for consideration and report.

Diamond Jubilee of the North-Eastern Centre

The President referred to his recent visit with the Secretary to the North-Eastern Centre for the latter's Diamond Jubilee celebrations, which had been a most successful and enjoyable meeting (see p. 137). He also expressed the Council's deep appreciation of the presentation by the Centre, to mark the occasion, of a signing desk which would stand in the entrance hall of the Institution building at Savoy Place.

The Diamond Jubilee of the Scottish Centre was also to be celebrated.

Members completing 50 years' membership

The President remarked on the large number of interesting letters of appreciation which he had received in reply to his letters congratulating those members who had recently completed 50 years' membership of The Institution.

John S. Robinson Memorial Fund

The Council approved arrangements for the execution of the trust deed in connection with the establishment of this fund (see January 1960 *Journal*, p. 52) and noted with appreciation that the securities being transferred by the founder would probably amount to nearly £7000 at their current values.

New generating plant

DURING 1959 the Central Electricity Generating Board have installed new generating plant in power stations throughout the country which gives a total additional electrical output capacity of 1670 MW (2¼ million h.p.).

Altogether 15 power stations, of which five were new ones, have been equipped with 21 turbogenerators, having an aggregate installed capacity of 1775 MW, and 23 boilers, giving an aggregate evaporative capacity of 14 700 000 lb/h of steam.

Notable among the new power stations is that at High Marnham, where the first of a number of 200 MW generating units commissioned by the C.E.G.B. has been brought into service. This unit—the largest yet installed—has a greater output capacity than any other operating in Western Europe. The associated boiler has an evaporative capacity of 1 400 000 lb/h of steam and the turbine stop-valve conditions are 2300 lb/in.^{2} and 1050° F. Reheating is provided to 1000° F after partial expansion of the steam through the turbine.

POST-OFFICE MECHANIZATION

THE Postmaster General has announced that the Post Office is launching a new pilot mechanized system for posting ledgers and calculating interest for the Post Office Savings Bank, and is investigating the use of computers to help mechanize the accounting processes which begin or end at Post Office counters. He said that the main problem was to prepare the data in machine language at source and so do away with the paper-work involved in manual conversion.

There are already 15 000 office machines in use by the Post Office today ranging from desk adders to large electronic computers. Dealing with some specific items of mechanization the Postmaster General said that as a result of using punched-card equipment for the preparation of telephone accounts, of which there are about 10 million a year, the Post Office had introduced machinery which enabled trunk-call tickets to be sorted at the rate of about 40 000 per hour as compared with a speed of about 3000 per hour by hand. A computer in the supplies department had cut by two-thirds the time taken to obtain key facts needed to keep the stock of some 25 000 different items of engineering stores adequately, but not more than adequately, replenished.

The Post Office intends to continue its policy of developing to the full the application to its work of office machines and aids of all types, and hopes to solve larger problems by looking more and more to the electronic computer as a means of processing data.

Heat-dissipating valve-shield

IT has recently been established that the life expectation and reliability of electronic valves can be considerably improved by reducing the bulb temperatures without otherwise altering their operating conditions. Some of the older types of shield actually impair the performance of a valve by raising the bulb temperature.

A new shield has been designed at the Atomic Weapons Research Establishment which not only retains the valve in its socket and effectively screens it from electrical interference but also acts as an efficient dissipator of heat. Fins similar to those of nuclear-fuel-element containers help to achieve this.

The shield is intended for mass production, and tests on pre-production prototypes indicate that in all conditions they are more efficient than other kinds at present available commercially either in this country or in the United States. It has also been shown by initial tests that they are capable of reducing valve-bulb temperatures in certain conditions by about 90° C below the level at which the valves operate without shields, and that there is an improvement of about 30° C over the best type of shield so far available commercially.

Protection of semiconductor rectifiers

A short article based on a Utilization Section paper (3135) entitled 'The characteristics and protection of semiconductor rectifiers' by D. B. Corbyn, B.Sc.(Eng.), Member, and N. L. Potter, B.Sc.(Eng.), Graduate. The paper was published individually in November 1959 and will be republished in Part A of the Proceedings. It was read before the Utilization Section on the 10th December 1959 (see p. 136). The authors are with the English Electric Co. Ltd.*

RECTIFIER techniques have changed so greatly during the last few years that a complete re-examination of protection methods has become necessary. Germanium and silicon rectifiers have supplanted mechanical, selenium and mercury-arc rectifiers in a very wide field of application. The more recent advent of the controlled rectifier will still further accelerate development.

The new semiconductors are susceptible to damage by overcurrent owing to their small thermal mass and by overvoltage owing to breakdown phenomena. Adequate protection of rectifier equipment requires the establishment of ratings which give an adequate life, the control of voltage and current surges, the detection and disconnection of faulty cells, and the co-ordination of all the protective measures to prevent unnecessary interruption of output.

Voltage characteristics

All rectifier-cell failures eventually mean inability to withstand reverse voltage even though the primary cause may be overheating, overcurrent or overvoltage.

The safe reverse voltage is determined for each cell in working conditions (either real or simulated), i.e. by dynamic testing both in normal operating conditions and when voltage surges are applied.

Electronic methods using the main circuit voltage, synthetic voltage systems using two power supplies, and synchronous contactor methods are all suitable for measuring reverse characteristics. The safe recurrent reverse voltage is defined by a leakage-current limit, a reverse-power dissipation or voltage breakdown. In some rectifiers the reverse voltage which can be withstood for very short pulses is appreciably above the normal recurrent reverse voltage.

In practice, voltage surges always occur, and the recurrent peak inverse voltage which the rectifier can withstand must be chosen to have an adequate safety margin above the recurrent reverse voltage in the circuit. The exact ratio can be varied according to the application and methods of surge prevention.

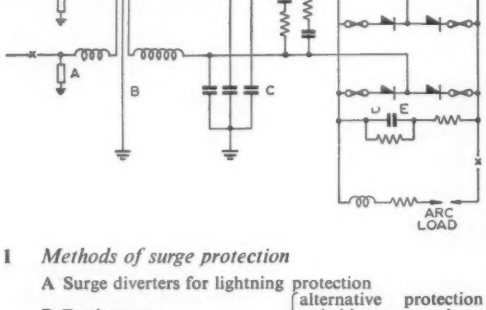
* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make the articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

Recurrent voltage peaks are produced by hole-storage commutation phenomena in the rectifier and controlled by *RC* networks. Transformer switching may produce very severe voltage surges depending partly on the type of circuit-breaker: the worst surges are usually produced by switching off an unloaded transformer. Surge arresters or *RC* networks on either primary or secondary reduce switching-surge voltage, and small capacitors from secondary lines to earth prevent the transfer of dangerous voltage through the interwinding capacitance of the transformer where the primary voltage is much greater than the secondary.

Surges due to lightning can be reduced to about 1·7 times normal peak voltage in favourable circumstances by the use of suitable surge diverters, but a factor between 2 and 3 is more usual.

Rectifier fuses are designed with limited arc voltages, and surges due to load-current chopping caused for example by d.c. circuit-breaker operation are controlled by *RC* networks on the rectifier output or transformer secondary.

The various methods of surge suppression are shown in Fig. 1.



1 *Methods of surge protection*

A Surge diverters for lightning protection
B Earth screen } alternative protection against switching surges due to capacitance coupling between transformer windings
C Low-inductance capacitors
D Capacitors for hole-storage protection and transformer-switching-surge protection
E *RC* circuit to absorb magnetic energy

Current characteristics, overloads and faults

The safe working current is limited by the junction temperature which must be chosen so that ageing effects are negligible in normal service and there is an adequate margin for overload and fault conditions to be controlled by the protective gear without harm to the rectifier.

Transient junction temperature can be reliably estimated by an electrical analogue of the heat-transfer system.

The current/time-survival curve is obtained for the rectifier cell, and the protective system is then designed to ensure that the safe current limit is never exceeded.

For high power outputs large numbers of rectifier cells must be connected in series and parallel and adequate care taken to ensure correct voltage and current distribution between cells in both transient and steady-state conditions. Fig. 2 shows the two basic connections, of which method a is preferred for most applications.

If one of the strings of cells in Fig. 2a fails and becomes a short-circuit it is essential to disconnect it rapidly before damage can be caused to healthy cells. This is best done by connecting a fuse in series with each string. The fault current which concentrates in the faulty cell is shared between a large number of healthy ones so that it becomes disconnected without harm to the remainder of the equipment. Fusing of individual cells is of no value for connections as in Fig. 2b.

Requirements of fuses for semiconductor rectifiers

The energy required to destroy a fuse can be found, as also can the energy to destroy a rectifier cell. The two components are then matched as already described.

The fuse must satisfy exacting requirements. It must have high breaking capacity and must limit both total energy lost and peak 'let through' current reached in a rectifier during a fault. It must also have a limited arc voltage, carry full load current indefinitely without deterioration, be small for mounting near the rectifier cell, and have stable, repeatable characteristics which can be co-ordinated with the time/current characteristics of other devices.

Protection co-ordination

The over-all protection is provided by the combined use of fuses, a.c. or d.c. circuit-breakers or contactors and possibly short-circuiters.

Internal faults are usually allowed to blow a fuse, disconnect the faulty cell and sound an alarm. In small equipments the circuit-breaker is usually opened to shut down the equipment and prevent overloading of healthy cells. In special cases operation continues at reduced load even on small equipments, and alarms are used to call attention to the need for load reduction. In large equipments a warning of cell failure is adequate since overloading is negligible and no immediate shutdown is necessary.

External faults must not blow fuses except as a last resort when all other means of protecting the rectifier equipment have failed.

This can be achieved by proper co-ordination of the circuit-breaker settings and fuse characteristics and still further assured by the use of a short-circuiter (which usually operates in well under 2 millisec) where appropriate.

In the rare event of a bolted short-circuit on the output terminals of the rectifier equipment, rectifier fuses are liable to blow before the a.c. breaker can operate when using normal transformer reactances. This can be prevented by using abnormally high transformer reactances but the power factor is lower, regulation is worse, and such a transformer is usually more costly and frequently has a rather high copper loss.

The risk of such a fault is very small and usually acceptable. The feeder resistance in most works d.c. power supplies is such that feeder short-circuits at the load end are cleared by the feeder fuses or circuit-breakers without any risk of blowing rectifier fuses.

Finally, voltage surges are controlled by a combination of

2 *Series and parallel connections of rectifier cells*
a Series b Parallel

RC networks and surge diverters, and the rectifier-cell voltage is chosen in relation to the precautions.

Protection in practice

In the practical application of semiconductor rectifiers a number of related problems arise which vary with the application.

To give warning of fuse operation a convenient method is to connect a small 'striker pin' fuse across each main fuse. When the main fuse clears the striker pin is ejected, sounds an alarm and when necessary trips the equipment.

For industrial power supplies it is usually adequate to achieve all protection with an a.c. breaker and the rectifier fuses. A feeder fault will operate the main a.c. breaker, set at about $3\frac{1}{2}$ times full load, without blowing the rectifier fuse. Direct-current circuit-breakers are not usually necessary and the risk of a full bolted short-circuit on the main output busbars is very small. Some precautions are necessary for operation in parallel with machines, mercury-arc rectifiers or mechanical rectifiers.

Furnace loads are often liable to short-circuit and require either current-limiting reactors or transductors together with careful measures to prevent voltage surges.

Electrolytic loads are very steady, have neither severe overloads nor short-circuits and are generally free from voltage surges.

A major risk is a lightning strike on the overhead supply lines, and very careful voltage-surge protection, usually by means of surge diverters, is essential.

Alternator excitation

Alternator excitation is a growing application often requiring over 12 months' continuous service without a shut-down. For this reason rectifier sections may be made withdrawable under load, and auxiliaries are duplicated. Such rectifiers are frequently subjected to very heavy current surges when a fault occurs on the main alternator stator and are specially rated for this purpose. Severe voltage surges are usually absent.

Rectifier traction using high-voltage alternating current on the catenary is growing rapidly. The major risk is that of a lightning strike, necessitating careful surge prevention preferably by a combination of capacitors and surge diverters. Motor flashovers occasionally happen and the fuses and circuit-breakers are co-ordinated and transformer reactance is chosen to prevent fuse-blowing. Designs should preferably minimize the number of fuses and it should always be possible to drive the train home even if a rectifier section has failed or a motor flashover has occurred.

Control of voltage surges

An appendix to the paper examines the magnetic energy stored either in the leakage field of a loaded transformer or in the iron core of an unloaded transformer. It is shown that the upper value of the capacitance required to reduce voltage rise on switching out to any assigned value can be calculated for various conditions, and a nomogram is given. In practice very much lower capacitances usually suffice but the cost of this surge prevention is so small that there is no serious disadvantage in fitting oversize capacitors. 621.314.63 : 621.316.91

High-voltage-insulator performance

A brief account of a Supply Section paper (3014) entitled 'Research on the performance of high-voltage insulators in polluted atmospheres' by J. S. Forrest, M.A., D.Sc., Member, P. J. Lambeth, B.Sc.(Eng.), Associate Member, and D. F. Oakeshott, B.Sc., Member. The paper was published individually in November 1959 and will be republished in Part A of the Proceedings. It was read on the 18th November 1959 at Savoy Place (see p. 132). The authors are at the Central Electricity Research Laboratories.

FLASHOVER of insulators of 132kV power lines and substations in industrial districts became a serious problem in the early years of the Grid system.

Research on the problem started by the C.E.B. and continued to the present day has yielded much useful information. Flashover due to industrial and saline pollution still occurs however, sometimes with serious consequences on the 132kV and 275kV networks. For example approximately 0·6 faults/100 route-miles occur annually on the 132kV Grid, of which 40% are due to industrial and 60% to saline pollution.

Industrial pollution should decrease in future; but as more generating stations are sited on the coast trouble from salt may present an increasing problem. Furthermore the use of higher transmitting voltages not only increases the insulation difficulties but also makes the consequences of flashover more serious. Thus it has been necessary to conduct research on insulators for use at 132 and 275kV where many problems still require solution and also at 380kV as a prospective transmission voltage.

To evaluate the performance of an insulator it is energized for a long period at maximum service voltage in the polluted atmosphere of the Croydon insulator-testing station: the leakage current is recorded and any flashover noted. The performance is then evaluated primarily in terms of the time to flashover and when necessary of the number of leakage-current surges in a given period. Comparison with other insulators also yields useful information. Figs. 1 and 2 show the test towers for 132kV and 380kV insulators.

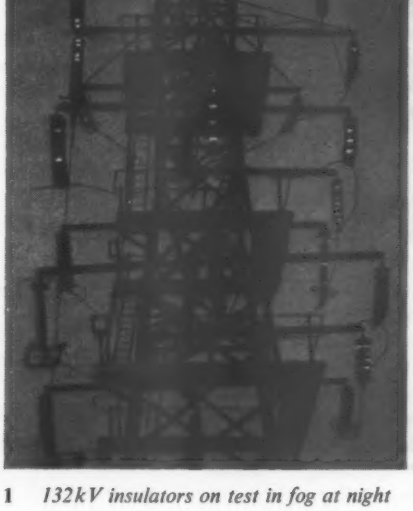
Effect of shape and size

One important outcome of the investigations into the effect of insulator shape and dimensions was the confirmation that leakage-path length is the predominating factor in determining the performance of conventional porcelain or glass insulators. It was found that the 'figure of merit' (ratio of length of leakage path to over-all length of insulator) should be about 3 for an anti-fog insulator.

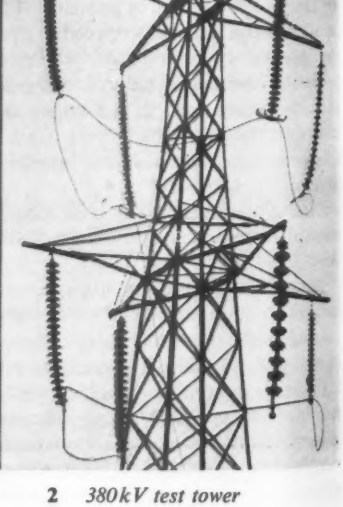
'Langstab' rod insulators of the type popular in Germany were compared with cap-and-pin insulator strings of equal lengths. The latter performed better at 275 and 380kV, but at 132kV the results were not decisive.

Grease coatings

The performance of porcelain or glass insulators can be greatly improved by applying various treatments to make the surface water-repellent and of high resistance in all conditions. Thus coating insulators with thick hydrocarbon greases has given good results both in investigations at Croydon at all test voltages and in service. The surface soon becomes extremely dirty through adherence of dirt to the surface, but



1 *132kV insulators on test in fog at night*



2 *380kV test tower*

the grease engulfs this pollution and good surface properties are maintained.

Silicone compounds have been used also, but any advantages they may have over ordinary greases are offset by the high cost. A coating of thick grease will be satisfactory for two years. A water-repellent surface is obtained also with the oil-bath insulator in which an oil reservoir is incorporated in each unit of a post or suspension insulator together with a cowl to prevent the loss of oil during rain and high winds. Experience with such insulators at 132, 275 and 380kV has been quite good, but they have been found to be vulnerable to coke-dust pollution.

Semiconducting glazes

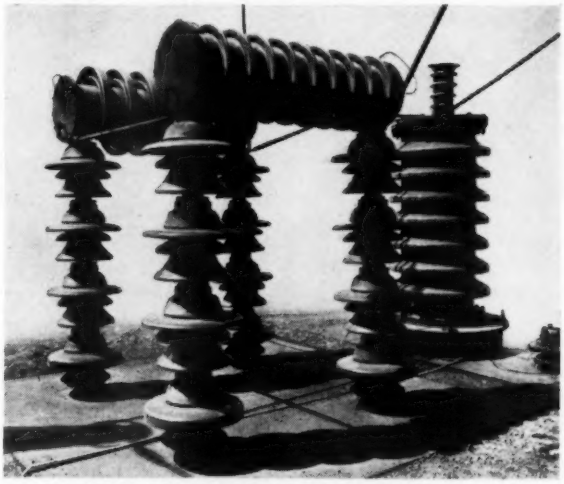
Another and very effective way of improving the performance of procelain insulators is to use a semiconducting ceramic glaze to control voltage distribution. Unfortunately deterioration can occur rapidly in pollution conditions through removal of the conducting components of the glaze, and this has been shown to be an electrolytic process. Nevertheless many resistance-glazed sealing ends and other insulators of a near-cylindrical shape have given a number of years of satisfactory service. A new barium ferrite glaze has been developed which laboratory tests have shown to be more corrosion-resistant.

Various insulators for 380kV have been energized at Croydon for three years, and some of these types should be suitable for operation in this country.

High-voltage d.c. systems

Outdoor line and station insulation for high-voltage d.c. systems associated with the cross-Channel link has been tested for two years at Croydon using 115kV d.c. In Fig. 3 are shown the rectifier and ballast capacitor of the d.c. supply. Dust precipitation on surfaces at or near earth potential by the electric field determines the *initial* dirt distribution, but in a few weeks normal weathering and redistribution of the stress brought about by the deposits themselves result in a nearly uniform fouling.

Leakage-current surges occur with direct just as with alternating current, and generally the predominating factors in insulator performance appear to be the various surface heating and drying effects. About 30% more insulation seems to be required for high-voltage d.c. systems than for a.c. systems of the same peak voltage.



3 *Rectifier and ballast capacitor for 115kV d.c.*

Artificial-pollution tests

The natural-pollution test takes several months, and to give more rapid results an artificial-pollution test is being developed. In this the surface deposits are built up as in service with the normal working voltage applied to the insulator. A spray of salt solution is blown onto the energized insulator, and its performance is observed. Investigations made on a bushing and post insulators at 85kV indicated that the method is roughly equivalent to a long-duration test. Promising results have been obtained, and further development of this technique is in progress. 621.315.62 : 621.317.333

Frequency patterns for multiple-radio-channel routes

A brief account of an Electronics and Communications Section paper (3033) with the above title by B. B. Jacobsen, B.Sc.(Eng.), Member. The paper was published individually in November 1959 and will be republished in Part B of the Proceedings. It was read before the Electronics and Communications Section at Savoy Place on the 7th December 1959 (see p. 133). The author is with Standard Telephones and Cables Ltd.

During the last decade radio links have been used increasingly to transmit television signals or signals through large groups of telephone channels over long distances where previously only cable circuits were used.

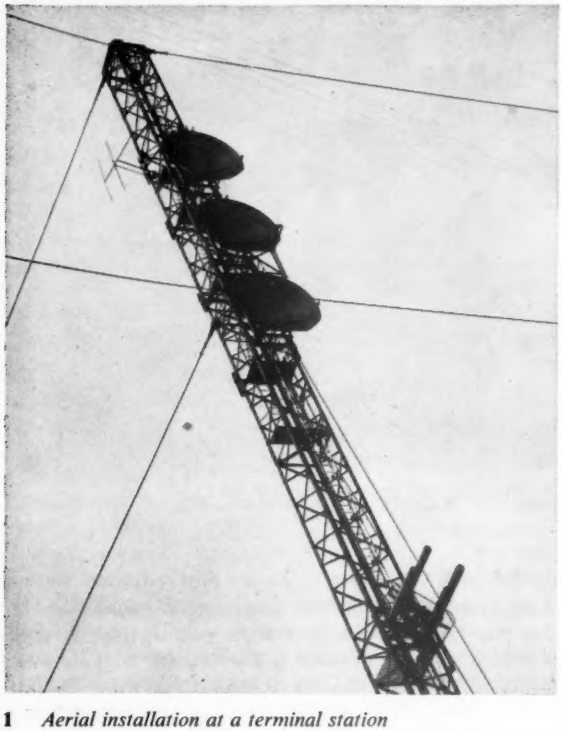
The input signal to a radio link, known as the baseband, is the equivalent of the frequency band used in coaxial-cable systems and carries the telephone channels in the same way, i.e. each telephone channel is given a bandwidth of 4kc/s in which the telephone message is transmitted as a single sideband.

A one-way radio link is approximately the equivalent of a single coaxial pair, but on the radio route each baseband transmitted uses an individual frequency band whereas in a coaxial cable each baseband is directly transmitted on an individual coaxial pair.

The radio channel transmits the baseband as frequency modulation of the radio carrier, and each radio channel requires amplification at intervals of about 30 miles along the route. This takes place in a repeater station which also changes the frequency so that the retransmitted channel after amplification

does not interfere with the received channel (in cable systems the repeater spacing is about 6 miles and there is no frequency change at the repeaters). Usually the radio channel is not demodulated at a repeater station.

The economy of radio routes is improved when a large group of radio channels share the repeater-station building



1 *Aerial installation at a terminal station*

and aerials, and it is current practice to design for six radio channels in each direction of transmission. This requires a total bandwidth for the group of about 400 Mc/s. On a given route groups may be used at frequencies near 2000 or 4000 Mc/s, and groups at 6000 Mc/s are now under consideration.

Aerial system

A terminal or a repeater station for three two-way radio channels uses a single aerial for transmitting and receiving the radio channels on one leg of the radio route. At repeater stations another aerial is used for the other leg of the route and if more than three two-way channels are required a further set of aerials is added. The second set is cross-polarized, i.e. axially rotated through 90° relative to the first set, and the frequency bands used in connection with the two sets of aerials are interleaved.

One aerial and its feeder are therefore shared by three transmitting channels and three receiving channels. Each of these has an individual frequency band allocated to it and is effectively connected to the aerial only at frequencies in its individual band. The channels are connected to the feeder by means of aerial branching filters. The degree of selectivity required of the filters in order to avoid mutual interference between the r.f. channels depends very much on the choice of frequency pattern for the r.f. channels and their local-oscillator and image frequencies.

Frequency patterns

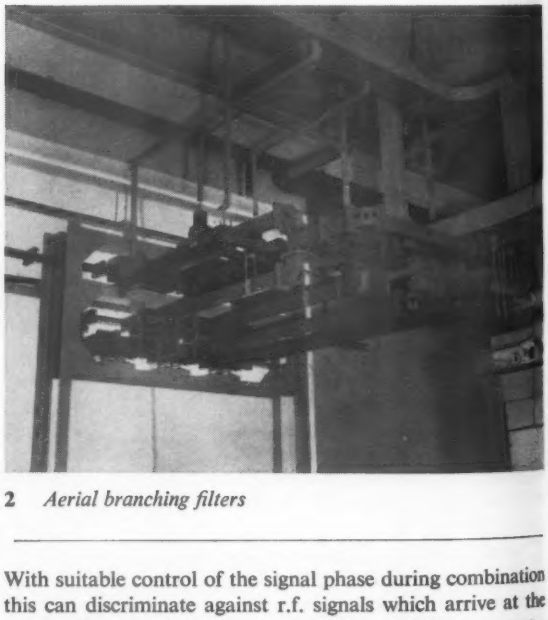
The paper outlines how to find an advantageous pattern for these frequencies, i.e. one which gives rise to the lowest selectivity requirements and therefore to the simplest filters while the over-all bandwidth occupied by a group of channels on the route is held at a desirable figure (e.g. 400 Mc/s).

A favourable arrangement of frequencies is found which has been adopted internationally for use in frequency bands near 2000 and 4000 Mc/s.

Radio-relay routes of the type discussed are widely used for long-distance transmission, and the equipment is capable of carrying up to about 1000 telephone channels or one television channel per radio channel. New developments being considered will increase the capacity to 1800 telephone channels.

Equipment

Fig. 1 shows the aerial installation at a terminal station. Each aerial consists of a waveguide horn and a paraboloidal reflector. Normally only two would be required for up to 6 r.f. channels: these are the lower ones. The upper aerial is required to make 'diversity' reception possible. For this the signals received on the highest and lowest aerials are combined after the aerial branching filters and before entering the receiving equipment, thereby forming a 'steerable aerial'.



2 *Aerial branching filters*

With suitable control of the signal phase during combination this can discriminate against r.f. signals which arrive at the aerials after reflection from the sea in the case of an over-water path. Reflected signals would give rise to destructive interference, i.e. loss of signal, if such steps were not taken.

3 *Station equipped for two 2-way r.f. channels*
The receive channels are equipped for diversity reception

Fig. 2 shows more clearly the aerial branching filters which are visible on the left of Fig. 3. These are equipped on three levels: the middle and lowest levels are for the lowest aerial in Fig. 1, the transmitting filters being on the lowest level and the receiving filters on the middle level. The upper level of filters is connected to the upper (diversity) aerial in Fig. 1. The waveguide circuits for combining the outputs from the filters on the middle and upper levels can be seen in Fig. 2.

621.396.2 : 621.396.65

Relaying quantity for feeder protection

A synopsis of a Measurement and Control Section paper (3137) entitled 'Selection of relaying quantities for differential feeder protection' by Colin Adamson, M.Sc.(Eng.), Associate Member, and E. A. Talkhan, B.Sc., Ph.D. The paper is published this month in Part A of the Proceedings. The authors are in the Power System Laboratory, Department of Electrical Engineering, Manchester College of Science and Technology.

DIFFERENTIAL feeder protection in general uses a single relaying quantity derived from all phases of the system being protected. The authors give a comprehensive analysis of the nature of this relaying quantity for the whole range of single shunt faults and all likely combinations of phase-sequence quantities extracted from the faulted system. The analysis includes the well established case of the summation transformer, this device having an output which contains positive, negative and zero phase-sequence components of current.

The analysis is presented in the form of curves giving the relaying quantity in terms of the important components of the various phase-sequence impedances of the power system. From these curves it is possible to compare the different ways of deriving the single-phase relaying quantity and thence to specify the general rules for selection of phase-sequence networks.

In order to provide a comprehensive method for determining a differential relaying quantity in magnitude and phase, a general chart has been developed; from this the magnitude and phase of the relaying quantity derived from any specified phase-sequence network may be obtained graphically in terms of the positive and zero phase-sequence reactances and the zero-sequence resistance of the power system. 621.316.925

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available in due course

Electricity supply metering

A synopsis of a Measurement and Control Section paper (3194) entitled 'The measurement basis of electricity supply metering' by J. W. Skinner, B.Sc.(Eng.), Associate Member. The paper is published this month in Part A of the Proceedings. The author is at the Royal Military College of Science.

THE author first establishes the precise significance of 3-phase power, reactive volt-amperes and total volt-amperes; then examines the suitability of these quantities as a basis for a tariff system; and finally analyses the possible metering circuits to determine what they actually measure and what are their errors.

The accepted definitions of power, reactive volt-amperes and total volt-amperes are established for a single-phase circuit, and the relation between these and the physical conditions of energy flow is examined. The extension of these concepts to 3-phase systems reveals the somewhat arbitrary nature of the quantities which form the basis of many metering systems.

Consideration is then given to what a metering system should attempt to measure and whether the integrated values of watt-hours, reactive volt-ampere-hours and total volt-ampere-hours, together with some indication of maximum

demand, give adequate information for the assessment of tariff charges.

The analysis of 3-phase metering circuits is made in terms of symmetrical-component theory. The possible circuits are tabulated and the total measured quantity is specified as a function of the power and reactive volt-amperes of the positive-, negative- and zero-sequence components. By comparing these data with the symmetrical components actually present in any particular conditions, the suitability of the methods of measurement and their errors are readily derived. 621.317.38

Impedance relay using Hall effect

A synopsis of a Measurement and Control Section paper (3136) entitled 'An experimental impedance relay using the Hall effect in a semiconductor' by Prof. H. E. M. Barlow, Ph.D., B.Sc.(Eng.), Member, and J. C. Beal. The paper is published this month in Part A of the Proceedings. Prof. Barlow is Pender Professor of Electrical Engineering, and Mr. Beal is in the Department of Electrical Engineering at University College, London.

The authors describe a new type of 'definite' impedance relay applicable to the protection of power transmission systems. Its operation is based on a differential balance, in normal conditions, between the output from Hall effect in a semiconductor element and a rectifier unit. The experimental results obtained demonstrate the success of this instrument in principle and show that it has many advantages over the usual induction type of impedance relay. 621.316.925.451 : 621.382

Displacement governors in steady-state conditions

A synopsis of a Supply Section paper (3179) entitled 'The performance of displacement governors under steady-state conditions' by Prof. J. C. Prescott, D.Eng., Member, and A. K. El-Kharashi, B.Sc., Ph.D., Graduate. The paper is published this month in Part A of the Proceedings. Prof. Prescott is Professor of Electrical Engineering, King's College, University of Durham, and Mr. El-Kharashi is in the Department of Electrical Engineering there, on study leave from Ain-Shams University, Egypt.

The method of speed control most generally used at the present time relies on the centrifugal governor which controls the power admitted to a driving machine, generally a prime mover, in relation to the difference between the machine shaft speed and a selected basic or no-load speed.

Other methods of control are however possible, and one which appears to have certain advantages is that in which the power input is controlled in relation to the angular displacement between the machine shaft and another shaft which rotates at a defined and constant angular velocity. This has been called displacement governing and an attempt is made here to investigate the performance of displacement governors when controlling the power supply to turbo-alternators working in the steady state.

The performance of such governors in transient conditions has already received attention, but as far as the present authors are aware the steady-state performance has not been explicitly treated before. 621.316.718.5 : 621.313.322-81

Improved electron-trajectory tracer

A synopsis of a Measurement and Control Section paper (3165) entitled 'An improvement to the electron-trajectory tracer' by J. Vine, M.Sc., and R. T. Taylor. The paper will be published in Part A of the Proceedings. The authors are with Associated Electrical Industries Ltd.

To increase the accuracy of the trajectory tracer improved methods of field determination on the resistance network have been investigated. One of these—an interpolation system applicable to axially symmetric fields—is described. This system has been constructed, and some results obtained with it for trajectories through an electron lens are given. These are compared with corresponding results obtained without the interpolation device and with results obtained by other methods.

The interpolation system provides significantly increased accuracy for this particular type of problem with little extra complication in the operation of the trajectory plotter.

621.317.75

More-precise measurement of capacitance

A synopsis of a Measurement and Control Section paper (3159) entitled 'Improvements in the precision measurement of capacitance' by G. H. Rayner, B.A., and L. H. Ford, M.Sc., Associate Members. The paper will be published in Part B of the Proceedings. The authors are at the National Physical Laboratory.

All measurements of capacitance and resistance at the N.P.L. depend ultimately on the Campbell standard of mutual inductance and on frequency. Hitherto capacitance has been obtained from mutual inductance and resistance using a Carey–Foster type of network. The precision obtained with this in the Astbury bridge has been considerably improved since it was constructed 20 years ago, and an accuracy of repetition of about five parts in 10^6 is now obtained.

Capacitance can also be derived from resistance and frequency; a Wien bridge has recently been constructed for this purpose. It has been designed to make a single precise measurement of capacitance (the repetition accuracy is two parts in 10^6) and thereby to complete a system of three measurements relating capacitance, resistance and mutual inductance in conjunction with frequency. 621.317.335

CORRESPONDENCE

SYMBOLS FOR SPACE CO-ORDINATES

I WAS interested to see in the September 1959 *Journal*, p. 533, Prof. Barlow's plea for the standardization of Cartesian, cylindrical and spherical co-ordinates. I am periodically involved in teaching electronics and so heartily agree with the need for simplification wherever possible. I note that in his diagram the x axis is shown vertical in each case.

Electronics students over here in Canada, where practical work alternates with theory, normally use cathode-ray oscilloscopes as laboratory tools even before they understand the internal working. With practically all the oscilloscopes in use here, unless the two axes are labelled 'Horiz' and 'Vert' they are marked x and y. The x axis is then the horizontal one, and the y axis is vertical.

It seems to me that when rationalizing the several co-ordinate systems the x and y axes should be made to agree with the standard which has for long been built into the electronic hardware used in practice.

In radio-receiver and relay circuit-diagrams the normal system is for the signal to pass through from left to right (like reading a book). The natural extension, which is generally followed, is to show the direction of propagation also as horizontal and from left to right. If, as Prof. Barlow suggests, the x direction should normally be the direction of propagation, it follows that the direction should be horizontal. This fits in with what is already standardized as the x-axis direction on oscilloscopes.

A *Mr. Voigt's suggestion*

The drawing of diagrams to make the x-axis direction horizontal from left to right and the y-axis direction vertical (see Fig. A) will eliminate the confusion Prof. Barlow hopes to avoid. In addition it will minimize confusion when switching from theory to electronic hardware.

P. G. A. H. VOIGT, B.SC.(ENG.), ASSOCIATE MEMBER

Apartment 'A'
655 Annette Street
21st December 1959 Toronto 9, Canada

[Prof. Barlow writes: Mr. Voigt has given another good reason why we should retain the x co-ordinate of a Cartesian system as the principal direction of propagation of an electromagnetic wave, basing this on the need to relate theory and experiment as represented by the conventional display of a transmitted signal on a cathode-ray-oscillograph screen.

As he says, a horizontal x axis is generally desirable from this and other points of view, and I entirely agree with him. The only reason Fig. 1 accompanying my first letter (September 1959 *Journal*) was so oriented as to bring the z co-ordinate horizontal was to make easy comparison with the alternative arrangement using z for the principal direction of propagation. As will be seen in my Fig. 1 the direction of the power is shown along the x co-ordinate, requiring, for a TEM wave, that the electric field should be along the y co-ordinate and the associated magnetic field along the z co-ordinate. This orientation is completely at variance with what has unfortunately become common practice in dealing with the analysis of electromagnetic-field problems.]

REVIEW OF 'ELECTRIC-CIRCUIT THEORY'

THE author of the review of the book on 'Electric-circuit theory' by F. A. Benson and D. Harrison (December 1959 *Journal*, p. 730) should learn to write the Queen's English before he ventures to criticize the writings of others. What is a manner which is 'breathless and loosely-linked'? 'Workaday' is not in my copy of Murray's English Dictionary. How does a little theory 'spread pretty thinly' and how does one explain the basis of the 'circuit concept' and 'treat' it 'comprehensively or formally'. I have not read the book, but, from my knowledge of the work and ability of the two authors, I am sure it will be of value to teachers and students of many universities.

PROF. E. W. MARCHANT, D.SC., F.C.G.I.,
PAST-PRESIDENT, HONORARY MEMBER

Brook Farm, Grendon
5th January 1960 Atherstone, Warwickshire

[The reviewer of the book referred to by Prof. Marchant writes: I thought that the book (i) failed to explain the electromagnetic-field basis of the circuit concept, what its limitations are, and how its parameters are defined; and (ii) presented a modest amount of theory not in general terms but rather as a series of discrete examples. The text, I felt, did not match its title: it was pedestrian and 'workaday' (Chambers, Shorter O.E.D., Webster, Fowler).

Prof. Marchant is tilting, presumably, not at opinion but at metaphor. Butter spreads thinly: why not theory? One is hurried from place to place and gets breathless. It is fruitless to argue about this, the vexed matter of style. Forty years' devotion to the master-hand—'Tomorrow, and tomorrow, and tomorrow . . .' has five different metaphors in the powerful, compelling lines of a single sentence—may still have left the reviewer inept.]

PHOTOEMISSION ON FILM

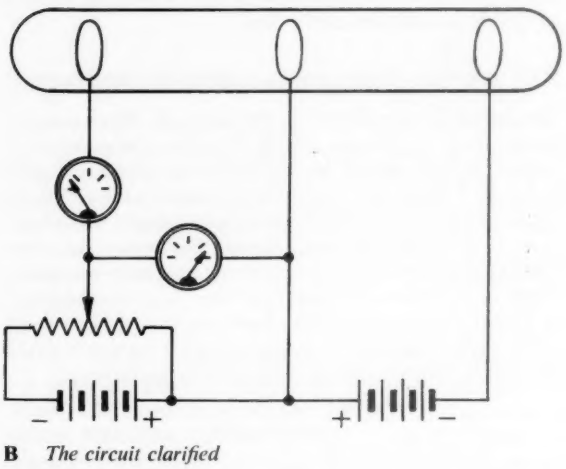
THE still from the film 'Photo-emission' reproduced on p. 694 of the December 1959 *Journal* is very instructive on another than the subject intended.

If the circuit is examined it is seen to be incorrect. Now the picture has been previously reproduced in another journal. It seems fairly certain that the error has not been noted by many for this particular still to be reproduced.

The reason why the error has not been immediately apparent—and this in a film designed as a visual aid—is that the lay-out of the circuit is muddled and untidy. No attempt appears to have been made to so delineate the wiring that the

potential relationships of the electrodes—which is the point at issue—appeal directly to the eye. If they had, the error would have stuck out like the proverbial sore thumb.

In a visual aid that lives up to its name there should be no necessity to trace wiring in order to establish basic relations. A circuit can usually be drawn to emphasize the particular relationships it is desired to establish, and Fig. B illustrates one lay-out which clarifies the circuit.



B *The circuit clarified*

The moral to be drawn on the wider front than the purely visual side is that a circuit should be laid out in a manner to bring out clearly the principles and interrelations involved. In industry this allows easier checking in the drafting stage, it makes the circuit more easily comprehended by inspection personnel, and it will ease any subsequent maintenance operations.

In passing, a strange inconsistency in the still shows one of the battery symbols drawn the wrong way round in respect to the positive and negative signs designating its poles.

. . . and by the Educational Foundation for Visual Aids too!

F. G. SWIFT, ASSOCIATE MEMBER

208 Shooters Hill Road
8th January 1960 Blackheath, London S.E.3

[The Chief Executive Officer of the Educational Foundation for Visual Aids, Dr. J. A. Harrison, writes: Mr. Swift is quite right—there is an elementary mistake in the still from the film 'Photo-emission'.

When however he attempts to use this particular example to stress the importance of lay-out of circuit diagrams he is on weaker ground. There is in fact little evidence to support his contention that few noticed an error which would have been immediately obvious had the circuit been drawn differently.

Before the still was made many, including a number of experts, had seen the film. No one spotted the mistake. When however the still was printed, contrary to what Mr. Swift says, it was immediately spotted by a large number.

It could I suppose be argued that had the circuit been drawn differently the error would have been noticed on the film and there would have been an even greater response to the still. But if the film is seen it will readily be appreciated that other factors are involved and provide a more valid explanation.

The error occurred in a single shot in a 20-minute film. The purpose of this shot was to show the effect of a retarding voltage on the electrons. Attention was focused on the moving electrons, extremely well shown in animation, and on the variations in voltage. The circuit diagram was static; it showed how the retarding voltage was produced which, in context, was of only minor importance. It was barely noticed at all and the same would have been true however the circuit had been drawn. But with the still it was entirely different. It was not in context; lacking movement it had no focal point; the circuit was of equal importance to the rest and the error was therefore easily spotted.

This is in no way to excuse the error or to belittle the importance of circuit lay-out but it does explain how even experts concentrating on one essential point can overlook an elementary error elsewhere.]

THE ELECTRICAL ENGINEER'S VIEW OF THE HOME

IN the December 1959 *Journal*, p. 708, you publish the findings of The Institution's Panel on Adequate Wiring under the heading of The electrical engineer's view of the home. I venture to disagree firmly with the paragraph which refers to kitchens.

1. With electric cooking condensation is considerable
2. Washing machines do not avoid the need for boiling of certain articles such as handkerchiefs, towels and pillow-cases (and also sheets if these are laundered at home). These articles also require bringing to boil from cold.

I suggest there is much in favour of a cool larder as there is doubt on the advisability of returning certain foods to the refrigerator after they have been cooked.

E. W. ASHBY, B.SC.(ENG.), MEMBER

36 Woolacombe Road
5th January 1960 Liverpool 16

[The Chairman of The Institution's Panel on Adequate Wiring for Electrical Installations in Buildings, Mr. J. I. Bernard, B.SC.TECH., MEMBER, writes: On Mr. Ashby's first point, the very slight amount of condensation caused when electricity is the source of heat for cooking may be more or less according to the type of food cooked, the temperature of the walls of the kitchen and the amount of moisture their finish will allow them to absorb. Cold outside walls finished with glossy paint naturally produce more condensation than warmer walls finished with distemper or other absorbent surface. But the main fact referred to in our full reply to the questionary is that electric heating does not of itself produce water vapour.

With conservative methods of cooking it is no longer necessary to allow a large quantity of steam to evaporate when cooking vegetables etc. Another possible source of steam, jam-making, is usually confined to the summer months when it is natural to open a window.

On the second point, some housewives may cling to the idea of boiling 'whites' but this is not really necessary with modern laundry appliances. American housewives for example are very keen on spotless linen and hygiene but clothes are no longer boiled anywhere in the United States.

On Mr. Ashby's final point, I know of no reason why cooked foods should not be kept in a refrigerator and the ability to do so is commonly regarded as an important advantage.]

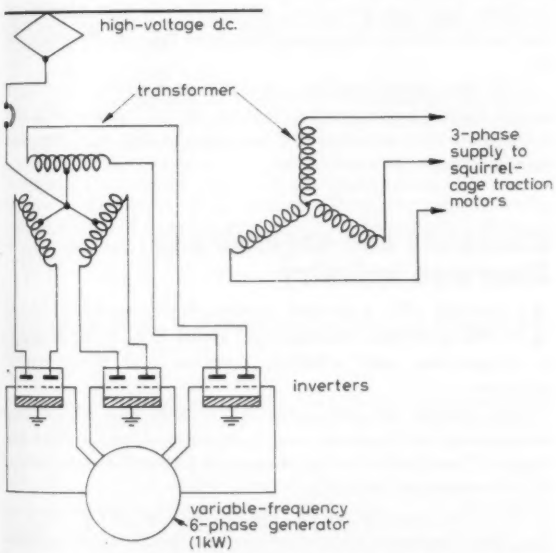
RAILWAY ELECTRIFICATION

THERE are a lot of the world's railways electrified on the 1500- or 3000-volt d.c. system. As we have already made large capital expenditure on the fixed installations, it seems unwise now to change over to the 50c/s system just to obtain locomotives with better operating characteristics. This being so, the position should be examined to see if better and lighter d.c. locomotives could be built, and studies made already of a.c. locomotive potentialities should be of use here.

I visualize in the future d.c. locomotives carrying inverters to feed 3-phase squirrel-cage traction motors, the circuit diagram being as in Fig. C. The variable-frequency 6-phase a.c. generator is of about 1kW capacity, driven by a small d.c. motor. The frequency would be capable of being varied from zero to say 80c/s.

Fig. C shows a transformer disposed between the inverters and the squirrel-cage motors. This may not be necessary and connections may be possible direct from inverter to traction motors.

A further innovation would be gearless 18-pole induction motors, quill-mounted, driving the wheels through a spring

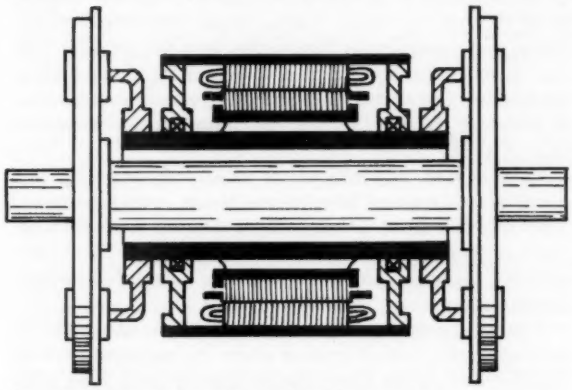


C *Inverters feeding 3-phase squirrel-cage traction motors*

drive as shown in Fig. D. This arrangement lends itself admirably to the spring-type drive which has already proved itself.

Gears and gear-cases are among the dirtiest pieces to handle in railway workshops and the elimination of these items would be welcomed there. A squirrel-cage motor lends itself very well to being designed for a large number of poles. A design which immediately suggests itself for say 54in. wheels could have a stator 42in. in diameter and a rotor 34in. in diameter.

Locomotives of this type, even with four gearless motors, should be able to exert a starting tractive effort of 40000lb which is enough to accelerate a 500-ton train up a gradient of 1 in 100 at 0·5m.p.h./sec. It would also be able to go at any



D *Quill-mounted gearless squirrel-cage motor*
wheel diameter 54in.; motor diameter 42in.; rotor diameter 34in.; core length 18in.; number of poles 18

maximum speed as determined by mechanical considerations and inverter and transformer ratings.

A B_0–B_0 locomotive design should weigh no more than say 70 tons. I am not suggesting that there are no problems; there are plenty, mainly of course in connection with the inverters, but as I see the position the difficulties are not insuperable. The problem of pulsation of the d.c. supply caused by the inverters coinciding with the pulsation of the rectifier-fed overhead line will have to be solved.

H. CHARNLEY, ASSOCIATE MEMBER
Brook House
662 Preston Road
Clayton le Woods
nr. Chorley, Lancashire

12th January 1960

CIRCUIT TRENDS IN DOMESTIC SOUND AND BROADCAST RECEIVERS

I WOULD like to thank Mr. Page for his helpful comments on my article (October 1959 *Journal*, p. 569) and for his kindly calling my attention in his letter (January 1960 *Journal*, p. 12) to the recently developed limiter-discriminator circuit.[1,2]

I agree entirely with him that the performance of the typical ratio detector is inadequate in severe conditions of multipath propagation. Unfortunately the receiver manufacturer has hitherto had to strike a compromise between downward-modulation handling-capacity and over-all sensitivity for, as I mentioned in the article, the public generally speaking are reluctant to use external aerials and, as a consequence, the retail distributor, when comparing various receivers, is mainly concerned with their basic sensitivities.

Consideration of this compromise arises in the case of both the ratio detector and the limiter-discriminator recommended by Mr. Page.

Correspondence (continued)

Unfortunately this latter circuit is not really as simple or inexpensive as Mr. Page suggests in his letter.

Functionally the replacement of the ratio detector by the dynamic-limiter/discriminator in a typical a.m./f.m. commercial receiver resulted in an improvement in a.m. rejection and an improvement of downward-modulation capacity of from 40 to 75% at high levels of signal input. The receiver sensitivities and discriminator bandwidths were the same for each case. It was noted however that very accurate tuning both of the receiver and of the third-harmonic rejector was required to maintain the a.m. suppression above the recommended limit of 35dB.

In addition to the discriminator transformer and associated two diodes it requires an i.f. transformer, a third-harmonic rejector circuit and a low-impedance diode to form the independent limiter. These components together with a more complex alignment procedure lead to a substantial increase in receiver cost.

It would appear that this circuit could well be adapted to the more expensive class of receiver where the improved linearity obtainable from the Foster–Seeley discriminator is an additional attraction.

F. A. RODWELL, B.SC.

Highfield House
Durham

16th January 1960

1. SPENCER, J. G.: 'F.M. receiver using new dynamic limiter', *Wireless World*, November 1959, p. 492

2. SPENCER, J. G.: 'An f.m. receiver incorporating a new type of limiter and discriminator', B.B.C. Engineering Research Dept. Report No. G. 076, December 1959

OBITUARY

LAWFORD STANLEY FOSTER GRANT

Lawford Stanley Foster Grant who died in Montreal, Canada, on the 17th December 1958 was born in Swansea on the 30th August 1878.

He was an articled apprentice for three years and then served in various positions in industry until 1901 when he joined British Insulated and Helsby Cables, Prescot, as a superintendent. He became chief engineer and manager for Canada and the United States in 1907. He went to Canada in 1909 as managing director of the company which was later absorbed by British Insulated Callender's Cables. In 1913 he joined the Eugene F. Phillips electrical works in Montreal as general sales and contract manager.

As treasurer and managing director of the company he became the pioneer of copper-rod rolling in Canada when in 1917 he recommended the construction of the first mill. This was erected at Brockville and began production in 1922. In 1930 when control of the company was taken over by Automatic Electric of Chicago he was appointed president of the re-formed Phillips Electrical Co. He resigned in 1936.

During the Second World War he came out of retirement to assist in metals' allocations for the Wartime Prices and Trades Board of Canada. Initially he was appointed copper controller in Ottawa. At the close of the war and for some time following he was administrator of non-ferrous metals for the Canadian Government.

During the time of his active business life he contributed a great deal of knowledge to the electrical wire and cable industry in Canada.

He is survived by a son.

He joined The Institution as an Associate Member in 1903 and was elected a Member in 1912. He served as the Oversea Representative of the Council for Canada from 1909 to 1933. J. M. T.

Disposal of radioactive waste

THE discharging of radioactive waste products into the sea was strongly criticized at a meeting convened jointly by the International Atomic Energy Agency and Unesco in Monaco recently. More than 300 scientists from 32 countries took part in this first international conference on the disposal of radioactive wastes.

Oceanographers pointed out that too little was known about the great ocean depths for the deep trenches to be used indiscriminately as atomic rubbish heaps. They disagreed however on the time taken for water from the ocean-bed to reach the surface, some estimating 1500 years while others thought 50, adding that marine organisms can transport radioactivity through the various layers.

The problem of waste disposal had two solutions: some way must be found either of storing the by-products of atomic research and industry safely until their radioactivity disappeared (sometimes hundreds of years) or else of treating them to a point where they could be discharged without danger into rivers, oceans or the atmosphere. Soviet representatives considered that no radioactive waste at all should be put into the ocean, while the British maintained that it could safely be done with low-level wastes if proper precautions were observed.

It was brought out at the conference that at present waste products represent far less man-made radioactivity than the fall-out from nuclear explosions. The amount being put into the Irish Sea from Windscale for example is only 1/200th of that in the Atlantic Ocean resulting from fall-out of strontium 90.

With the operation of nuclear-powered ships however there would be more radioactive elements in the oceans and the circulation of such elements required urgent and detailed investigation.

Scientists and engineers in American industry

IN January 1959 American business firms employed about 780000 scientists and engineers, about 35% being engaged in engineering and scientific research and development activities.

The recently released data on scientific and engineering employment are based on a survey conducted for the National Science Foundation by the Bureau of Labor Statistics of the U.S. Department of Labor.

Scientists and engineers in the industry sectors included in the survey represent approximately two-thirds of the scientists and engineers employed in the United States. The other third work in Government agencies, educational institutions, non-profit-making organizations, or are self-employed.

Industries with the largest groups in January 1959 were aircraft and parts, electrical equipment, and chemicals and allied products. Each had more than 75000 scientists and engineers; combined, they employed one-third of the total number engaged in private industry.

Employment of scientists and engineers in private industry was about 4% higher in January 1959 than in January 1958.

PAPERS AND MONOGRAPHS

published individually this month

PAPERS

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings including the discussions thereon and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

High-speed light output signals from electroluminescent storage systems *Paper* 3217M: *Part B*

G. R. HOFFMAN, PH.D., B.SC., D. H. SMITH, M.SC., PH.D., *and* D. C. JEFFREYS, M.SC.

THE possibility that a matrix of electroluminescent cells could be used for storage of information in digital form has long been realized. The problems involved in reading information from a simple type of permanent store are discussed. It has been shown that the read-out time is limited by the afterglow of the phosphor and, for a particular (ZnS, Cu, Cl) phosphor, it is 25–30 microsec per digit.

A theoretical calculation of the discrimination ratio, i.e. the ratio of the output signal from a '1' to the interference signal obtained when a '0' is selected, shows that it should be possible to operate matrices with as many as 64^2 cells. This conclusion is not borne out by measurements made on experimental panels; these suggest that 32^2 is about the maximum. Results obtained in the paper are regarded as preliminary since arbitrary choices have had to be made concerning some aspects of the operation of the matrices. There is little doubt that considerable improvement in performance is possible.

To be read on the 1st March 1960

Introduction to the theory of masers with particular reference to the travelling-wave maser *Paper* 3220E: *Part B*

P. N. BUTCHER, PH.D.

THIS is an introduction to the theory of solid-state masers with particular reference to the travelling-wave maser. The relevant properties of paramagnetic ions are described and the quantum theory of maser action is outlined qualitatively. A semi-classical treatment is developed which is based on the classical equation of motion of a magnetic dipole. It is used to evaluate the engineering characteristics of a travelling-wave maser which employs the comb type of slow-wave guide.

To be read on the 7th March 1960

Some considerations in the application of power rectifiers and convertors *Paper* 3215U: *Part A*

J. P. McBREEN

THE author examines the suitability and selection of semiconductor and mercury-arc rectifiers and convertors for various applications. He discusses the number of phases to employ and how this question is affected by supply and other considerations. The effect of rectifier-fed rolling-mill and winder drives on the supply system is studied.

A summary is given of the characteristics of the transformer connections in more general use and some notes are provided on their employment. Mention is made of parallel operation and some examples are furnished of how phase multiplication is achieved. Possible faults and their prevention are described; protection requirements are outlined; and reference is made to installation and ventilation. In the main, only British practice is treated.

To be read on the 10th March 1960

Low-drift transistor chopper-type d.c. amplifier with high gain and large dynamic range *Paper* 3227M: *Part B*

I. C. HUTCHEON, M.A., *and* D. SUMMERS

THE authors describe a transistor chopper-type d.c. amplifier which is intended for use in the field of process measurement and control and has a voltage drift below $\pm 10\mu$V and a current drift below $\pm 4 \times 10^{-9}$amp.

The forward gain in the steady state is about 10kV/μA and 15 volts/μV and in consequence the full output swing of 0–5 volts is provided by an input signal little greater than the drift. The application of sufficient over-all negative d.c. feedback therefore enables input signals of 0–10mV or 0–4μA to provide full output with an accuracy within $\pm 0{\cdot}1\%$.

The low drift is obtained by operating the transistor chopper at 200c/s, stabilizing its temperature within $\pm 2°$C, and providing suitably stable waveforms to drive the transistor and compensate for its voltage offset.

The a.c. gain prior to the demodulator is only 50 volts/μA, the remaining gain, of about 200, being provided by a low-drift d.c. amplifier which is connected as a feedback integrator and used to smooth the demodulated output. This arrangement enables the system to handle, with a minimum of saturation, the large error signals which occur during a rebalancing operation and so maintain a fast response to large changes in input signal.

The system is first analysed in general terms, and expressions are derived which describe its performance and act as a guide to the design of this type of amplifier.

To be read on the 15th March 1960

The logmotor—a cylindrical brushless variable-speed induction motor *Paper* 3149U: *Part A*

PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., E. R. LAITHWAITE, M.SC., PH.D., J. F. EASTHAM, M.SC., *and* L. S. PIGGOTT, M.SC.

IN a conventional induction motor the synchronous speed at the rotor surface is set by the phase difference between currents in adjacent slots and the spacing of the slots. The synchronous speed may be increased by changing the phase of the current in each slot progressively so as effectively to stretch the poles. The authors describe a transformer arrangement, giving a multiphase output, which can provide such a 'phase-stretching' system to be used to supply the stator of a squirrel-cage induction motor.

The transformer is similar to a conventional phase-shifting transformer except that the pitch of each coil of the primary is proportional to the logarithm of its distance from a fixed point in the system. The primary and secondary of the transformer are analogous to the C and D scales of a slide-rule, and movement of the primary relative to the secondary results in a variation of the phase increment between adjacent secondary coils.

The secondary is connected to the stator winding of the motor

in such a way as to provide a uniform-velocity field in the latter, the velocity being varied by adjusting the position of the primary of the transformer. The method of construction of an experimental machine is described and test results over a speed range of 4 : 1 are included.

Date of reading not yet fixed

MONOGRAPHS

Life expectancy of electrical machines with variable loads *Monograph* 354U

JOSEPH BEN URI, DR.-ING.

MODERN economics demand a lowering of costs and prices, and this usually calls for a reduction in the amount of material employed. The difficulty is that some of the insulation materials in use have a cellulose base, which means that their ageing may be endangered if the temperature is higher than 110°C, since above this temperature the cellulose materials tend to change quickly in consistency and mechanical strength.

The life expectancy of electrical machines should be seven years when they are continuously under rated load. General equations for change in life expectancy with temperature have been experimentally and partly deductively found and presented by Montsinger and Bussing, and experiments prove that the equations are correct for continuous loads. But when the load changes, the heating and cooling periods must be taken into consideration. Short-circuits or heavy overloads can be dangerous.

Equations have been developed for load changes and for straight-line and exponential temperature changes, and it is shown that the cooling-off period especially can be dangerous and use up an appreciable part of the life expectancy of the electrical equipment in question. Sample calculations on transformer and intermittent motor loads are included.

Voltage and current transformation matrices *Monograph* 355E

I. CEDERBAUM, PH.D.

TRANSFORMATION matrices relating two adequate systems of simple network co-ordinates such as node-pair voltages or link currents belong to the class of unimodular or E-matrices. The author makes a distinction between the matrices corresponding to such voltage and current transformations and derives different sets of necessary conditions for each type.

Since the loop- and cut-set-to-branch incidence matrices are closely related to transformation matrices the discussion proposes new sets of necessary conditions for incidence matrices corresponding to systems of node-pair voltages or link currents. Examples are given of matrices which, while representing a voltage transformation, cannot represent a current transformation and vice versa. Another instance shows an E-matrix which can represent neither a voltage nor a current transformation.

Stabilization of control systems with backlash using a high-frequency on-off loop *Monograph* 356M

E. A. FREEMAN, B.SC., PH.D.

THE author introduces a method of stabilizing control systems which have backlash in their control sequence. The technique described employs an auxiliary loop to drive the motor across the backlash whenever the motor and load tend to separate. Requirements of the auxiliary loop are deduced and a phase-plane analysis is developed for a second-order position-control system with this loop operative. Analysis shows that the system with backlash is effectively linearized. It is also proved that impacts between motor and load are avoided.

To establish the feasibility of the method an analogue-computer study is presented. Results from the analogue show that the technique leads to considerable improvement in the step-function response. Variation of the system damping and of the ratio of inertias is investigated. The arrangement stabilized by the technique behaves essentially as a linear system.

Conductivity of oxide cathodes. Part 8—Current-dependent matrix dissociation *Monograph* 357E

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* EDITH MACARTNEY, M.SC., B.SC.

AN attempt is made to determine the nature of the dissociative action which accompanies the passage of a current through a barium-strontium-oxide matrix at 1020°K. Two identical oxide systems operating at a common temperature and passing the same quantity of electricity but at different rates might be expected to suffer the same mass of oxide dissociation. Experiment shows however that such is not necessarily the case and that dissociation mass is determined by rate of application of electricity rather than by the total quantity of electricity.

The products of dissociation are in ionic form, and experimental arrangements are made for the separate collection of the ions in chemical form on a relatively massive scale.

A working hypothesis is offered in explanation of the experimental observations.

Radiation from discontinuities in strip-line *Monograph* 358E

L. LEWIN

A METHOD of calculation which should be adequate for strip-lines of small spacing is proposed for the evaluation of the radiation of line-above-ground configurations.

An open-circuit is appreciably worse, from the point of view of radiation loss, than a short-circuit, with a right-angle corner at an intermediate level. The radiation from a matched post is slightly worse than from the short-circuit but it should be capable of considerable improvement if a terminating frame antenna is used. Formulae are given for the effects of reactive stubs, with applications to a simple resonator.

Some observations on waveguide coupling through medium-sized slots *Monograph* 359E

L. LEWIN

A QUASI-STATIC transmission-line technique, as used in antenna theory and modified to take into account effects of radiation damping, is applied to the problem of waveguide coupling through slots which may be large enough to exhibit resonance effects.

The waveguide environment significantly alters the value to be used for the slot characteristic impedance, although this quantity cannot itself be calculated by the present analysis. The method is applied in detail to axially coupled waveguides and to guides coupled, via a common broad wall, through crossed slots. A narrow slot needs to be very near resonance to give a coupling as large as that from a circular hole of comparable dimensions.

New design method for phase-corrected reflectors at microwave frequencies *Monograph* 360E

S. CORNBLEET, B.SC.

A METHOD is given for the design of a class of wide-angle reflectors in which the aberrations are reduced by coating the reflector surface with a dielectric. At microwave frequencies this dielectric may take the form of an array of metal plates or waveguides, and the constraint imposed by this form greatly simplifies the analysis.

The path of the feed point is chosen so that only selected rays from it are equally phased. It is then found that both of the reflector's profiles and the path of the feed point can be described by a single parameter. The residual aberrations of several cylindrical systems, including the corrected parabola and circle, are analysed to find a reflector for which the scanning arc is the circle with centre at the vertex of the reflector. A refocusing procedure, which is found to be necessary, produces this scanning arc. Experimental results in agreement with the theory are given.

The principle can be used to programme a step-wise procedure for the design of corrected surfaces using non-constrained natural dielectric coatings.

Effect of an additional non-linearity on the performance of torque-limited control systems subjected to random inputs *Monograph* 361M

J. L. DOUCE, M.SC., PH.D., *and* R. E. KING, M.SC.

THE authors discuss a technique for improving the response of a saturating servomechanism subjected to random signals. A non-linear error detector gives a considerable reduction in error magnitude for a large range of input signals. It is possible to design the additional non-linearity to optimize the performance of the system for all input magnitudes. This form of non-linearity has previously been shown to effect improvement in the response of such systems to step-function and sinusoidal inputs.

Experimental work verifies the predicted results for a particular system and shows that much latitude is permitted for the characteristic of the additional non-linearity.

Power flow and negative wave impedance in the dielectric-rod waveguide *Monograph* 362E

E. F. F. GILLESPIE, M.ENG.

IN MOST waveguides of practical interest the wave impedance, looking in the direction of propagation of the wave, is positive and its magnitude does not vary with position. In general a guiding structure supporting a hybrid mode, i.e. a mode having axial components of both the electric and the magnetic fields, can present a negative wave impedance.

The case of the EH_{11} mode on a dielectric rod is considered. For this mode the wave impedance is negative over part of the transverse plane and hence leads to regions of negative power flow if the usual interpretation of the Poynting vector is employed. The total power flow however is still positive since the negative power density and the negative wave impedance occur in only a restricted part of the cross-section.

The orthogonality of the fields is discussed. For hybrid modes the transverse electric and magnetic fields are not at right-angles to each other.

The surface-wave aerial *Monograph* 363E

W. HERSCH, PH.D., B.SC.(ENG.)

THE RADIATION from the open-circuited end of an externally dielectric-coated metallic waveguide can be controlled by varying the size of the guide and the thickness and/or the dielectric constant of the coating. A new type of aerial designed around this principle is given the name 'surface-wave aerial', and radiation-pattern measurements are used to confirm the theory underlying this type of radiator.

According to its mode of operation it belongs to the category of end-fire aerials, which are briefly reviewed to show that surface-wave aerials occupy a place in their own right among the many possible arrangements that utilize the end-fire effect to produce a directional radiation pattern.

The theory of the surface-wave aerial is developed in detail, a necessary preliminary step being a full theoretical analysis of the properties of the first-order cylindrical surface wave. A dielectric-coated cylinder which is approximately a wavelength in circumference can act as a waveguide for higher-order surface waves, of which the first order is an example.

The 'characteristic equation' is determined for the general case, from which the cut-off frequency, propagation coefficient and conditions in which propagation can take place are derived in turn.

Two specific cases are evaluated numerically and the results are used to calculate the polar diagrams of surface-wave aerials operating at 9 Gc/s.

The wavelength constant as well as the continuous radiation loss of a surface waveguide for which $\lambda g/\lambda_0 \simeq 1$ are measured directly and the data obtained are employed to account for the radiation pattern of very long aerials. An outline of future work is given.

NEW POWER STATION AT LOCH ERICHT

THE North of Scotland Hydro-Electric Board have placed contracts for the building of a power station on the eastern shore of Loch Ericht, some ten miles south of Dalwhinnie, and for the plant, a 2·2 MW turbo-induction-generator, to be installed in the new station.

The station will stand at the outlet of the existing tunnel from Loch Garry to Loch Ericht, part of the Rannoch section of the Grampian power scheme.

CONFERENCE ON ELECTRONIC STANDARDS AND MEASUREMENTS

THE second national conference on electronic standards and measurements, sponsored by the U.S. National Bureau of Standards, the Institute of Radio Engineers' Professional Groups on Instrumentation and Microwave Theory and Techniques, and the American Institute of Electrical Engineers, will take place from the 22nd to 24th June 1960 at the National Bureau of Standards Laboratories, Boulder, Colorado, U.S.A.

Six sessions are planned on: current and future problems in electronic standards; direct-current and low-frequency standards and calibrations; methods of measurement for materials; frequency and time standards; microwave standards and calibrations; and high-frequency standards.

Further information may be obtained from Mr. Herbert Finke, Polytechnic Research and Development Co. Inc., 202 Tillary Street, Brooklyn 1, New York, U.S.A.

INCREASE IN CAPITAL EXPENDITURE

THE Board of Trade announces that the latest estimates of fixed capital expenditure in the United Kingdom in 1960, made from forecasts sent to the Board by a sample of companies at the end of 1959, indicate that private industry and business now plan to spend 14% more than in 1959 on fixed assets for use in manufacturing industry and about 20% more on assets for other industries and services.

In the case of manufacturing industry the increase is made up of an estimated rise of about 17% in expenditure on plant, machinery and vehicles and an increase of about 8% in expenditure on building work.

BUS-LOADING RECORDER

LONDON Transport have fitted a passenger-loading recorder to one of their country buses.

The apparatus is actuated by the weight of the passenger as he takes his seat, and provides a continuous timed record on a roll chart of the number of seated passengers, from which can be deduced the loadings at points on the route, due allowance being made for late running.

The equipment consists essentially of a micro-switch for each seat which sends an electrical impulse to the recorder when the seat is occupied. The switches are set to operate at a pressure of 14 lb from a plywood flap, hinged at one edge, under each seat.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned except where otherwise stated

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Automatic control in Soviet industry. A report of a visit to the Soviet Union, May 1959. H.M.S.O., London, 1959. gratis*

THIS is the official report of six engineers who were invited to the Soviet Union for two weeks to study progress in automatic control applied to industrial production. The party was led by Prof. A. Tustin who recorded his first impressions in the September 1959 *Journal*, p. 521. The team found that analogue computers are extensively used in industrial control systems, while digital machines are becoming more freely available. There is more work done on control in the steel industry than the chemical, and priority has also been given to work on telemetering e.g. long gas-transmission pipelines and on control of electric power systems over long transmission lines. In addition to details of the institutes visited the report includes a note on discussions with the leader of an American team of digital-computer engineers who were there at the same time and one by Prof. Tustin on a subsequent personal visit to Warsaw. The report is distributed for D.S.I.R. through the British Conference on Automation and Computation.*

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: NATIONAL PHYSICAL LABORATORY

Symposium No. 10 **Mechanization of thought processes—Vols. 1 and 2.** H.M.S.O., London, 1959. 50s. (postage 2s. 11d.)†

THE two volumes contain the full proceedings of the symposium held in November 1958, including some 40 papers on pattern recognition, learning mechanisms, mechanical translation and automatic programming and the discussions which took place. The volumes are not sold separately. The symposium was reported in the January 1959 *Journal*, p. 31.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: RADIO RESEARCH

Special report no. 28 **The conversion of ionospheric virtual height–frequency curves to electron density–height profiles** by J. O. Thomas and M. D. Vickers. H.M.S.O., London, 1959. 3s. 6d.†

IONOGRAMS showing the equivalent height of a radio wave as a function of frequency can be used to derive the variation of electron density with height through the ionosphere. Electronic digital computers are employed and this report describes in detail the calculations involved in the conversion. It also explains what results will be available and how they can be obtained.

ELECTRICAL DEVELOPMENT ASSOCIATION

Electricity and productivity series no. 8 **Process integration and instrumentation.** London, 1959. 8s. 6d. (postage 6d.)

ONE of a series of eight dealing with specialized applications of electricity, this book includes descriptions of the means of sensing, measuring and controlling the variables which occur in manufacturing processes and shows how a more completely integrated process can be achieved. Many applications are quoted.

* Obtainable on application to the Hon. Secretary, Group B, British Conference on Automation and Computation, c/o The Institution of Electrical Engineers, Savoy Place, London W.C.2
† Obtainable from H.M. Stationery Office

NUFFIELD FOUNDATION

Fourteenth report. Report for the year ended 31st March 1959. London, Nuffield Foundation, 1959. gratis

GRANTS and fellowships awarded during the year include a grant of £15000 to establish at Brunel College of Technology, Acton, a research unit, one of whose studies will be to trace ways in which students' attitudes to work develop during their progress from school through the academic and industrial phases of sandwich courses. £12000 has been offered to Birmingham University over five years towards a research unit to study and advise on the placement and teaching of part-time technical students; this will include organizing a tutorial system at the selected technical college. The Foundation's interest in and policy towards the teaching of technology are stated in the introduction. The Foundation is also supporting work on a third digital computer, Edsac 3, at the University of Cambridge Mathematical Laboratory. Microwave techniques and very-high-speed transistors will be used.

PERGAMON PRESS

Plasma physics—accelerators—thermonuclear research (*Journal of Nuclear Energy: Part C*) [In English]

THIS new publication will be issued quarterly at £7 per volume to libraries, industry and Government bodies (rate A) and at £3 10s. per volume to private subscribers certifying that the the journal is for their personal use (rate B). Vol. 1, number 1/2, appeared in October 1959. Subject-matter includes any work which helps with the understanding of plasma physics; all work, in engineering or physics, directed towards the harnessing of thermonuclear reactions as a source of power; and theory, design and operation of particle accelerators, excluding their ultimate experimental use.

Full papers or abstracts are given depending on their relevance. Translations of appropriate papers from *Atomnaya Energiya* are included.

U.S. DEPARTMENT OF COMMERCE: NATIONAL BUREAU OF STANDARDS

NBS Circular 601 **Recorder survey: recording surfaces and marking methods.** Washington, D.C., 1959. 38 cents*

A SURVEY is made of traces and printed characters produced by inking, incision, impression, deposition, heat, light, electric discharge, electron beam, magnetism, chemical action or fluid streamlines. The three physical components of a recording system are described: the reservoir of material or energy, the marking point, and the surface on which the record is preserved.

NBS Monograph 4 **CRPL exponential reference atmosphere.** Washington, D.C., 1959. 56 cents*

THE development of an exponential model of atmospheric radio refractivity at the Central Radio Propagation Laboratory is outlined and a set of radio-ray tracings is presented.

WIRELESS WORLD

Guide to broadcasting stations. 12th edition. London, Iliffe and Sons, 1960. 3s. 6d. (postage 6d.)

ALL long- and medium-wave broadcasting stations in Europe and some 2500 short-wave stations of the world are listed. This new edition also includes lists of 1000 European v.h.f. sound broadcasting stations and most of the European television stations.

* Obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

SOME RECENT BOOKS

J. ALEXANDER

SCIENTIFIC MANPOWER

HILGER AND WATTS. 1959. 135 PP. 15S.

THE author was on the research staff of the Science and Industry Committee set up to examine the use made by industry of scientific discoveries. She was particularly concerned with the availability of technical manpower, and the volume is a summary of her investigations. These were thorough and intensive. They included visits to technical colleges in this country and senior technological institutions abroad, discussions with industry, and the use of questionaries for gathering information. As a result the book gives in a clear and concise way a fair and factual account of the many factors influencing the supply of scientists and engineers. Helpful statistics are presented and there is a chapter on the oversea approach to training technologists which contains several ideas of interest.

The text provides a valuable résumé of the development of technical education since the recent war which will be most useful to those who want a clear guide to the present situation.

R. AUDUBERT and S. DE MENDE

THE PRINCIPLES OF ELECTROPHORESIS

HUTCHINSON. 1959. 142 PP. 35S.

SOME of the physicochemical processes underlying separation by electrophoresis are described in detail and with considerable clarity. Separations both in free solution and in stabilized media are considered. Undoubtedly the best feature of the book is an interesting discussion of the complex processes occurring during electrophoresis on strips of filter paper. Data are presented which should help to define the optimum working conditions for this very widely used method of analysis.

Unfortunately the authors have failed to set reasonable limits to their endeavours and they include formulae for processes as different from electrophoresis as for instance the decay of radioactive elements. Furthermore a somewhat arbitrarily chosen set of examples of successes which have been achieved by means of electrophoresis is given. Worse still the standard of presentation as a whole and the applicability of some of the numerous formulae leave much to be desired. For these reasons, only those already well versed in electrophoresis are likely to find the volume of any value.

S. BEER

CYBERNETICS AND MANAGEMENT

ENGLISH UNIVERSITIES PRESS. 1959. 214 PP. 25S.

MR. Stafford Beer is Head of the Department of Operational Research and Cybernetics of a large and important industrial undertaking. One might have hoped, on reading his book, to find some contribution to the solutions that are so urgently needed for the problems of large-scale industrial management and organization.

Alas, no! It is mainly a rather excited declamation about the wonders of feedback, analogues and binary arithmetic. Well worn themes such as Grey Walters's tortoises, Ashby's 'homeostat', Turings's self-reproducing machines and so on are discussed in an exuberant style but without precision or critical appraisal. There is a pseudo-philosophical commentary that chiefly consists in indicating analogies in widely diverse fields and reaching doubtful conclusions from them.

The most likeable feature of the work is its enthusiasm. Mr. Beer splashes about like a baby enjoying itself in its bath. He floats great big words and makes them knock against each other and greatly enjoys himself. It seems churlish and unkind not to applaud.

He says in his preface with reference to the application of 'cybernetics' that 'the real barrier to success is not the intractability of the problem; it is the intractability of men'. This reviewer does not agree. Industrial managers are awake to new possibilities and are anxious to learn realistically how new mechanisms may be used to assist management and to improve the smoothness and economy of production. A sober book that explored these possibilities and gave examples of actual or possible applications of control techniques to industrial management would be welcome and would be widely read. On these topics the ratio of uplift and exaltation to realistic constructive work is already too high. Mr. Beer's volume has only made it higher.

It is in fact hard to see for whom it has been written. The preface explains that it originated as a number of popular lectures. But not all lectures deserve publication. The treatment is too superficial to be recommended to students of management and too unrealistic for students of engineering. Perhaps it will be read by the fringe who want intellectual excitement without demanding either realism or utility. That it will in any way increase the respect of managers for the people who call themselves 'cyberneticians' is most unlikely.

D. BLANC

DÉTECTEURS DE PARTICULES

PARIS: MASSON. 1959. 323 PP. N.P.

THIS describes the design, mode of operation and applications of the numerous types of counter that have been developed for the detection of ionizing radiations. These include ionization chambers, proportional counters, Geiger–Müller counters, spark counters, solid-conduction counters, photomultipliers, and Čerenkov and scintillation counters.

The treatment of the various forms of gas counter is comprehensive, but that of the more recent instruments is less satisfactory. For example, although the scintillation counter is of special interest for γ-ray and particle spectrometry and as a detector in fast coincidence circuits, these applications are not discussed, and the energy resolution and time resolution of the instrument are not considered.

The work will commend itself to French-speaking readers since it is one of the first on the subject in that language.

English-speaking readers, who already have the choice of several excellent books and reviews in their own language, will find the extensive tables and bibliography of value for reference.

E. BRENNER and M. JAVID

ANALYSIS OF ELECTRIC CIRCUITS

McGRAW-HILL. 1959. 703 PP. £3 14S.

THIS is a first-class publication. Although it does not go very far into circuit analysis (it stops short for instance of distributed circuits), what it does cover is comprehensive, thorough, general and formal. Intended for the sophomore-junior grade it would suit any enlightened student in a British university, college of advanced technology, or major technical college in his final years.

It takes a highly intelligent view of the subject. It seeks with success to avoid the artificial segregation into 'd.c.', 'a.c.' and 'transient' states, which are particular cases of a general circuit response. It opens, as any such work should but rarely does, with a discussion of what is meant by a circuit, how it is a simplification of a complex electromagnetic-field system, how its parameters are defined and what their limitations are. The differential equation of a circuit is its basic feature, and the principles of circuit behaviour rather than routine short cuts are its concern. 'The oscillogram is more important than the voltmeter reading.'

The early part deals with circuits no more intricate than the two-mesh but the treatment is exceedingly well done, with many illustrative examples and simple, clear methods. The later part deals with network functions, with more attention to systematic analytical techniques.

The reviewer sees in the book a treatment that has been germinating in his own mind for the past two decades. He has only the most minor—and arguable—points of criticism, concerned with the order in which the material is presented.

There have been two or three British texts on cognate subjects recently reviewed in these columns. Their authors could profitably study the present volume. Its content, format, generality and lively English style combine to produce an outstanding example of modern maturity in circuit analysis.

B. S. CAMIES

PRINCIPLES OF FREQUENCY MODULATION

ILIFFE. 1959. 147 PP. 21S.

THIS work treats the subject from a practical rather than theoretical viewpoint and will appeal more to the interested engineer and amateur than to the serious student.

The first part deals with the basic principles and theory of frequency modulation. An indication is given of the limitations of amplitude modulation in broadcasting, and the adoption and growth of f.m. in America and Great Britain are outlined. The standard theory of a.m., p.m. and f.m. is reproduced in some detail, with reference to sideband structure and bandwidth occupied.

A chapter is devoted to f.m. and interference, and the author's explanations of the mechanisms involved are particularly good. The numerical examples quoted are of great assistance in understanding the magnitudes of the quantities involved.

The best part is undoubtedly the section on 'Detection of f.m. waves' and even the operation of the ratio detector is explained with some conviction.

There are further chapters on 'Generator of f.m. waves', 'F.M. receivers' and 'Non-broadcasting applications of f.m.' The latter chapter is an attempt to include too much information in too small a space and the sections are somewhat scrappy. Perhaps because of this the reviewer had the impression that the emphasis was misplaced in several sections.

The text is well presented and the diagrams and illustrations are clearly labelled. For the practical engineer this moderately priced book is worth while.

W. G. CHACE and H. K. MOORE (*Editors*)

EXPLODING WIRES

NEW YORK: PLENUM PRESS. LONDON: CHAPMAN AND HALL. 1959. 373 PP. £3 16S.

THIS consists of three groups of papers presented to the April 1959 conference on the exploding-wire phenomenon organized by the Geophysics Research Directorate, Air Force Cambridge Research Center, and the Lowell Technological Research Foundation.

All the papers are concerned with the phenomena which occur when a fine wire is explosively vaporized by the sudden passage of a large current. According to the book, the effects are different from those which occur in the common electric fuse because of the higher rates of rise of current density used in exploding-wire experiments. This seems open to doubt however because at least some of the high-speed photographs in the volume show effects which are well known to fuse experts, such as multiple arcing, and the oscillograms give the usual high-voltage spike as the wire disintegrates into an initially poor-conducting column of metal vapour.

The first 14 papers deal with the theory and with oscillographic and photographic investigations of the exploding wire itself and its interaction with the power source. The second group of four papers is concerned with the shock waves associated with the wires, while the last eight papers, a very mixed bag, discuss applications.

The sudden interest in these wires is of course due to the fact that this is a method of obtaining plasmas having particle densities orders of magnitude greater than can be obtained in the more usual gas discharges.

The quality of the papers varies very widely: some are very good, demonstrating extremely effective high-speed photography and oscillography, but a few are rather poor and give the impression that their authors rushed into the field with very little attention to the literature.

Reproduction is by a photographic technique which does not flatter some of the oscillograms and high-speed photographs. Nevertheless most of the papers will be of interest to those working with plasmas or high-intensity light sources and also to those concerned with electric fuses.

C. W. CHURCHMAN and P. RATOOSH (*Editors*)

MEASUREMENT: DEFINITIONS AND THEORIES

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 274 PP. £3 4S.

THE concept of measurement is interpreted in this volume in a much wider sense than that used by engineers. It contains papers which were originally presented in 1956 at meetings of the American Association for the Advancement of Science and which, in this revised form, are contributed by 14 specialists drawn from physics, mathematics, philosophy, psychology, economics and sociology.

In some of these disciplines the restricted accuracy or repeatability of a measurement gives rise to the usual problems known to engineers, but in addition there is the question of precisely what information is given by the measurement of, say, intelligence or utility. The contributors are thus largely concerned with the meaning and implications of a measurement rather than with the practical difficulties of making the measurement. A wide variety of topics is dealt with, ranging from mathematical and logical models of measurement to psychological tests of preferences, from Heisenberg's uncertainty principle to managerial decisions.

An engineer will find little of direct value to him here, with the possible exception of a paper on the measurement of rare events. However, if he is interested in the philosophical problems lying behind information theory, he will enjoy reading some sections of the book.

E. M. GRABBE, S. RAMO and D. E. WOOLDRIDGE (*Editors*)

HANDBOOK OF AUTOMATION, COMPUTATION AND CONTROL—VOL. 2

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 1080 PP. £7

THIS is the second of three volumes, the first of which was reviewed in the April 1959 *Journal*, p. 251. Its main topic is the design and use of digital computers and data-processors, rather less than a quarter of the text dealing with analogue-computing devices. Unexpectedly for a 'handbook' most of it is pleasant to read: much effort must have been expended in linking up the contributions of the 41 authors and in making comparisons (e.g. between analogue and digital methods).

The principles of digital-computer programming, including automatic programming, are discussed intelligibly and in detail. Computing, data-processing, the handling of accounts, factory scheduling, language translation and game-playing are among the applications described, but detailed information about numerical methods appeared in Vol. 1 and only an inadequate summary is given here. The sections on digital equipment and computer design are up to date and include an excellent chapter on designing circuits for reliability and on marginal testing.

The description of analogue-computing devices is readily available in textbooks, but in addition there is helpful material on digital differential analysers, on mixed analogue- and digital-computing systems and on analogue–digital convertors.

This book is remarkably independent of Vol. 1, and on its own it would be a valuable acquisition in a library used by engineers interested, but not necessarily specializing, in computing devices. The large collection of references should be extremely useful although they have a strong American bias (like the rest of the work) and some may be difficult to trace.

H. GOLDSTEIN

FUNDAMENTAL ASPECTS OF REACTOR SHIELDING

LONDON: PERGAMON PRESS. 1959. 416 PP. £3 6S. 6D.

THIS volume enjoys a good reputation among engineers engaged in shielding calculations. It does not claim to be as comprehensive as other books available but sets out to deal thoroughly with the basic principles involved in shielding calculations for nuclear reactors (not sources or accelerators etc.). This it does in an entirely satisfactory manner.

Originally published in 1957, the material has been revised up to September 1958. The initial chapters give an outline of the nuclear physics and radiation biology concerned. Later sections analyse the sources of neutrons and γ-rays found in reactor structures, give a description of experimental work done in the United States and explore the methods of calculation of γ-ray attenuation and neutron penetration.

No attempt is made to interpret these results in an engineering manner. For example questions of shield cost and of methods of cooling are not covered. The text will therefore appeal most to those engaged in the relevant theoretical work.

E. H. W. HERSEE

A SIMPLE APPROACH TO ELECTRONIC COMPUTERS

BLACKIE. 1959. 104 PP. 12S. 6D.

THE author claims in his preface that his book is intended to explain how a computer works. Within the usual definition accepted by engineers this might be expected to indicate that at least some mention would be made of the hardware. With the exception of such statements as '. . . magnetic core storage . . . consists, in effect, of a large number of miniature magnets whose residual polarities can be changed individually . . .' (p. 38), there is no mention of computer construction and the text contains no illustration of a machine.

What the author has actually attempted is a simple account of logical design, which bears the rather dated stamp of the late D. R. Hartree's 'Calculating instruments and machines' and is rather out of touch with modern practice. This is followed by a chapter on programming and a section on special-purpose digital computers. Apart from one good feature—the careful emphasis on the difference between the address of a storage location and its actual contents—none of the matter seems to the reviewer particularly clear or simple.

The text ends with some chapters on 'analogue computers'.

This, to the author, appears to mean electronic differential analysers and it is surprising to find an excursion into differential and integral calculus in a work where discussion of digital multiplication and division is omitted because these operations are too complex.

Although the volume is well produced the author cannot be said to have succeeded in his purpose. Engineers and others who wish for a really simple explanation of digital computers would be better advised to read the excellent (and less expensive) publication 'An introduction to automatic digital computers' by R. K. Livesley, reviewed in the October 1957 *Journal*, p. 555.

J. F. HINSLEY

NON-DESTRUCTIVE TESTING

MACDONALD AND EVANS. 1959. 495 PP. £3 15S.

THIS work is written for those who have no knowledge of non-destructive testing and who wish to learn how this growing technology can be used for assessing the quality of materials and components.

The techniques available for detecting defects are described in great detail. It is pleasing to observe however that the scope of the text is not restricted to the detection of defects and that adequate attention is paid to the methods used for examining other factors which contribute to the quality of materials, such as surface condition, uniformity of composition and uniformity of structure.

The outstandingly good section is that which deals with radiography. In the chapters devoted to this topic the author presents the type of information which can be acquired only by years of experience.

From the long explanations given of many elementary physical concepts one gains the impression that the author has tried to present the subject in a way which he thinks will appeal to readers who have little scientific knowledge. If this is the case, then it is doubtful whether he has succeeded in his aim. To be of use the book requires a fairly good background knowledge of physics.

E. von KILINSKI

LEHRBUCH DER LUFTELEKTRIZITÄT

LEIPZIG: GEEST AND PORTIG K.-G. 1958. 141 PP. DM17

THIS brief treatment of atmospheric electricity is based on a lecture course given in 1954 and 1956 to students of meteorology and geophysics. For a subject in which new information is being accumulated at such a rapid rate as in atmospheric electricity this constitutes a serious limitation. It implies that much recent information is missing and that in some respects the book is already out of date.

On the other hand reference is made to the author's own recent measurements at the Potsdam Observatory. These are mainly concerned with the conductivity of the atmosphere, the earth's potential gradient, the registration of the air–earth conduction current, and the point-discharge current. These topics also form the basis of the main chapters of the work which concludes with a brief and somewhat inadequate section on cloud and thunderstorm electricity.

The volume is written in simple language which will be appreciated by students without prior knowledge of the subject. Its chief value to the more advanced reader lies in the description of basic measuring devices and in the occasional references to some little-known early German work.

O. KLEMPERER

ELECTRON PHYSICS

LONDON: BUTTERWORTH. NEW YORK: ACADEMIC PRESS. 1959. 248 PP. 32S. 6D.

'ELECTRON physics' is defined as the physics of the free electron, and the author uses this title for a work which bridges the gap between conventional theoretical electronics and pure physics.

It is unusual and gratifying to find in a single volume both the customary headings of electron optics, space charge, noise and relativistic effects *and* chapters dealing with the wave nature of the electrons, their spin, magnetic moment, etc. As well as the discussion of fundamentals, historical aspects of the topic are well covered. Treatment of the operation of practical devices is not really within the scope of the text and is limited to a chapter on electron detectors and brief mention of a few examples from the field of electron optics.

The book thus forms a useful addition to the literature of the subject and, in going some way beyond the undergraduate lecture courses on which it is based, should prove of use to students and qualified engineers alike. It is well illustrated and a large number of problems are included.

D. D. McCRACKEN, H. WEISS and T.-H. LEE

PROGRAMMING BUSINESS COMPUTERS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 510 PP. £4 2S.

THE general problems of programming are discussed in a clear and logical manner, using an imaginary system called Datac. There are chapters on flow charting, the logic of arithmetic, coding including editing and decision-making, loops or repetitive operations, and subroutines. The section on input and output devices is too brief to be of use. The chapters on machine-aided coding and sorting are clear and helpful. There is a brief description of random-access storage and verification methods, and a useful glossary and reasonable bibliography are included.

The volume cannot be used as a manual for learning programming, any more than a book on the theory of music can teach one to play the piano. It will however be of value to practising programmers to broaden their outlook and suggest useful lines of experiment.

J. MARKUS

HANDBOOK OF ELECTRONIC CONTROL CIRCUITS

McGRAW-HILL. 1959. 347 PP. £3 6S.

THIS is a collection of nearly 270 industrial electronic control circuits which were published in *Electronics* in 1956–59. It is

a sequel to two similar publications by the same author, namely 'Handbook of industrial electronic control circuits' and 'Handbook of industrial electronic circuits', which dealt with circuits developed before 1956.

It is divided into 23 sections covering nearly all industrial applications. Typical section headings include alarm circuits, computer control circuits, process control, telemetering, and nucleonic circuits. The operation of each circuit is adequately described and all necessary component values are given. The subject-matter is up to date and transistor techniques are well represented. A noteworthy feature is the detailed cumulative index which includes references to the two previous works.

Engineers working on developments in the field of industrial control will find this volume a mine of useful factual information which can save hours of searching through literature.

It is too advanced and specialized for normal teaching purposes but it can be recommended as a reference book for undergraduates carrying out experimental projects in their final year.

O. MOHR (*Editor*)

STEUERUNGEN UND REGELUNGEN ELEKTRISCHER ANTRIEBE

BERLIN: VDE-VERLAG. 1959. 414 PP. DM36

THIS fourth volume in a series contains 23 articles based on lectures at a convention in October 1958. They are well illustrated, are mainly descriptive and give a good survey of up-to-date control engineering in its various aspects.

Basic control elements and the application of induction motors, stator-fed a.c. commutator motors and transistors to electric drives are discussed. Some examples of advanced control techniques in the steel, paper, plastics and rubber industries are described. Other articles deal with mine winders, traction problems, and the application of analogue and digital computers to control-engineering problems. A 12-page bibliography adds to the value of the book.

M. SASIENI, A. YASPAN and L. FRIEDMAN

OPERATIONS RESEARCH

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 316 PP. £4 2S.

THIS is not a volume from which one can learn about the development and general application of all the techniques which have come to be included under the heading operations research. It is rather a textbook which illustrates certain of the basic topics in this field, those of a mathematical or statistical nature, and which shows how, from the complex situations of real life, simplifying assumptions can be made, the appropriate mathematical models of operations built up and the optimization procedures applied to them. It is written round 90 examples involving the principles and methods in question and has a good supply of problems for solution, mostly with hints or answers.

Following an introductory chapter on basic probability theory and one dealing briefly with sampling, including the simulation of actual sampling procedures by what are known as 'Monte Carlo methods', the examples solved deal with the most economic size of inventories, with the most effective replacement policies for items of equipment or staff, with waiting-line (or queuing) problems, with optimum strategies in competitive situations and with the allocation of limited resources, including elementary linear programming.

The last two sections introduce the as yet relatively incompletely investigated fields of what are called sequencing and dynamic programming. The first of these typically deals with the ways of selecting the most effective order in which jobs, each of which has to pass through some or all of a series of machines, can be arranged. The second tackles problems where a series of consecutive decisions are involved and the over-all optimal return cannot be arrived at by considering each decision separately.

It is the measure of the development of operations research in the United States that academic courses training practitioners in such a field have so developed as to call for an introductory publication of this type, providing a simplified approach to the techniques involved. The methods used are in general mathematical but the level of mathematics required is well within the compass of scientists and engineers. For those who want to get some insight into the developments in the techniques in question the book should provide useful and not-too-difficult reading.

J. R. SINGER

MASERS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 147 PP. £2 12S.

AFTER a brief introduction this opens with a chapter on induced emission and absorption of radiation in which various fundamental formulae are deduced, sometimes by classical and sometimes by quantum-mechanical arguments. That is followed by a discussion of gaseous masers. A section on electron paramagnetic resonance precedes others on the two-level solid-state maser, the three-level cavity maser, and travelling-wave masers.

The author states in the preface that his purpose is to present an introductory treatment of the subject but it is pertinent to ask for what class of reader the book is intended. The large body of electrical engineers who have heard of masers and would like to know a little more about them will probably discover it too detailed for their needs. Also they are likely to find the chapter on electron paramagnetic resonance and certain other sections largely unintelligible. They are better served by one or other of the review articles that have appeared.

On the other hand, for those actively working on masers—mostly physicists—who already have a good knowledge of solid-state theory, the treatment is rather superficial. However if they are beginners in this field it will give them a general idea of the problems to be solved, and the comprehensive lists of references which are well classified will indicate where more detailed information is to be found.

The work is well printed, has many excellent diagrams and within the limits which the author has set himself is reasonably complete and up to date.

M. SCHWARTZ

INFORMATION TRANSMISSION, MODULATION, AND NOISE

McGRAW-HILL. 1959. 461 PP. £4 5S. 6D.

THE title, although justifiable, might mislead some readers, and it should be stated here that information theory in the sense used by Shannon and Wiener receives only a cursory outline. Most of the material is more directly applicable to the understanding of actual communication systems.

The book is described as a first-year graduate text, intended for students who have previously completed or are currently pursuing allied courses in circuit electronics. It states the basic principles of the more important modulation techniques both continuous-wave and sampled, linear and quantized. The way in which their performance is circumscribed by noise and by bandwidth limitation is made clear, the necessary mathematical methods of time/frequency transformation and statistics each having an introductory chapter.

The style of writing is informal and frequently rather loquacious, fortunately without much detriment to the sense. Like many American treatments, it is unlikely to dovetail into any English engineering course, but with its problems, illustrative examples and *ab initio* treatment of most topics it is quite suitable for self-study.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

ASPDEN, R. L. 77

Electronic flash photography; a survey of principles and practical techniques in industry, research and radiography*

London: Temple Press, 1959. pp. xvi, 192. 23 × 14cm. 37s. 6d.

It not only deals with the photographic considerations involved when electronic-flash equipment is used but gives details of the tubes' characteristics and the circuits employed. Applications of special equipment for research and radiography are described.

BORN, M., and WOLF, E. 535.3

Principles of optics; electromagnetic theory of propagation, interference and diffraction of light

London: Pergamon Press, 1959. pp. xxvi, 803. 25 × 17cm. £6

A systematic and comprehensive discussion of those optical phenomena which may be treated in terms of Maxwell's theory.

CAMIES, B. S. 621.396.619

Principles of frequency modulation; applications in radio transmitters and receivers, and radar*

London: Iliffe, 1959. pp. viii, 147. 22 × 14cm. 21s.

An account of the fundamentals of frequency modulation and its application in receivers, transmitters, microwave links, radar, telegraphy and facsimile transmission. This book is reviewed on p. 118.

CHURCHMAN, C. W., and RATOOSH, P. (*Editors*) 53.08

Measurement: definitions and theories*

New York: John Wiley. London: Chapman and Hall, 1959. pp. viii, 274. 24 × 15cm. £3 4s.

A collection of papers for a symposium in New York in 1956 giving contrasting approaches to the problem of measurement, from the standpoints of physics and of the social sciences. Reviewed on p. 119.

CONDOYANNIS, G. E. 40 = 82

Scientific Russian*

New York: John Wiley. London: Chapman and Hall, 1959. pp. xii, 225. 17 × 13cm. 28s.

This is arranged as a series of 12 lessons illustrated by many helpful tables and lists of words. After explaining the Russian alphabet it describes the structure of the language, examines the variations of endings of nouns, adjectives and verbs, deals with tenses, participles and irregular verbs, etc. Reviewed in December 1959 *Journal*, p. 730.

CULLWICK, E. G. 538.3

Electromagnetism and relativity; with particular reference to moving media and electromagnetic induction. 2nd edition

London: Longmans, 1959. pp. xxiii, 291. 22 × 14cm. £3 3s.

This is an advanced book concerned with moving bodies and electromagnetic induction. It gives a detailed explanation of the special theory of relativity and its application to electromagnetism and also an original elementary theory which is applied to various classical experiments.

DEKKER, A. J. 62.002.3

Electrical engineering materials*

Englewood Cliffs: Prentice-Hall, 1959. pp. ix, 208. 23·5 × 15·5cm. £2 14s.

Discusses the dielectric properties of insulators in static fields, behaviour of dielectrics in alternating fields, magnetic properties of materials, the conductivity of metals, the mechanism of conduction in semiconductors, and junction rectifiers and transistors. Reviewed in January 1960 *Journal*, p. 44.

DIMO, P. 621.315.014.3

Analiza sistemelor electroenergetice prin separarea nodurilor si utilizarea curentilor de scurtcircuit (Analysis of power systems by separation of nodes and the use of short-circuit currents)

Bucharest: Editura Tehnică, 1959. pp. 294. 21 × 15cm. 19s. approx.

FISCHER, F. A. 621.395.61

Grunzüge der Elektroakustik (Fundamentals of electro-acoustics). **2nd edition**

Berlin: Fachverlag Schiele und Schön GmbH., 1959. pp. 210. 21 × 15cm. DM24

This is a mathematical treatment of the subject and the reader is expected to have some familiarity with the differential and integral calculus and with the general theory of oscillations.

FROST, B. R. T., and WALDRON, M. B. 621.039

Nuclear reactor materials

London: Temple Press, 1959. pp. vii, 79. 21·5 × 14cm. 12s. 6d.

An outline of the present state of the art and science of reactor materials.

GERMAN-PROSOROVA, L. P., and VINOGRADOVA, N. I. 413 = 82

English–Russian radiotechnical dictionary

Moscow: State Publishing Office for Technical and Theoretical Literature, 1957. pp. 524. 20·5 × 13cm. 15s.

HAWLEY, W. G. 621.317.333

Impulse-voltage testing*

London: Chapman and Hall, 1959. pp. xvi, 183. 21 × 13·5cm. 32s.

This work is intended both for university students and for laboratory staff and covers impulse-voltage technique and testing, including basic theory which is dealt with in terms of Heaviside's operational calculus. It considers single- and multi-stage impulse generators, voltage measurement, and the testing of transformers, overhead lines, power cables, capacitors, etc.

HENNEY, K., and others (*Editors*) 621.38

Electronic components handbook—Vol. 3*

New York and London: McGraw-Hill, 1959. pp. 180. 29 × 22cm. £3 17s. 6d.

Gives factual information on various types of transformer and inductor and on jacks, plugs, sockets, terminals, knobs, dials and other miscellaneous items.

HOLBROOK, J. G. 517

Laplace transforms for electronic engineers*

London: Pergamon Press, 1959. pp. xiii, 259. 22 × 14·5cm. £2 10s.

Begins with an introduction to the complex variable, the remainder of the book being concerned with the Laplace transform. It is claimed to be a rigorous treatment although written for self-study. Network analyses of special waveshapes and pulses and other applications are dealt with. Reviewed in January 1960 *Journal*, p. 46.

HUNT, K. H. 531.8

Mechanisms and motion

London: English Universities Press, 1959. pp. xiv, 114. 22 × 14cm. 21s.

In this book a new approach is made to the fundamental principles in mechanical-engineering and other courses to degree and diploma level.

KARPLUS, W. J., and SOROKA, W. W. 518.5

Analog methods; computation and simulation. 2nd edition

New York and London: McGraw-Hill, 1959. pp. xiii, 483. 24 × 15·5cm. £4 17s.

This is a comprehensive survey of analogue methods and techniques. It gives a broad insight into the nature and operation of linear and non-linear computing elements and discusses the interconnection of these to solve equations. There are problems and laboratory experiments for the student, and bibliographical references.

KLEMPERER, O. 537.122

Electron physics; the physics of the free electron*

London: Butterworth, 1959. pp. xi, 248. 22·5 × 14·5cm. 32s. 6d.

Based on a course of lectures. Historical notes are followed by a survey of the methods of producing electron rays, problems of electron motion and of electron optics, and the fundamental properties of charge, mass, wavelength, spin and magnetic moment. This book is reviewed on p. 120.

KUČERA, J., and HAPL, J. 621.313.04

Vinuti elektrických strojů točurých (The winding of electrical rotating machines)

Prague: Československé Akademie Věd, 1959. pp. 899. 24·5 × 17·5cm. n.p.

It is primarily intended for those concerned with the design of electrical machines. It covers in great detail all types of winding of d.c. and a.c. single- and 3-phase commutator machines.

LEVENS, A. S. 518.3

Nomography. 2nd edition

New York: John Wiley. London: Chapman and Hall, 1959. pp. viii, 296. 25 × 17cm. £3 8s.

A book on the theory and construction of alignment charts. It discusses circular nomograms, projective transformations and the relationship between concurrency (Cartesian) and alignment nomograms with applications to experimental data.

MAGNER, T. F. 413 = 82

Manual of scientific Russian*

Englewood Cliffs: Prentice-Hall, 1959. pp. iii, 101. 27 × 21cm. 36s.

The first part of this work deals with the Russian alphabet and the structure of the language. This is followed by a section which summarizes the rules of grammar and a vocabulary of words frequently met in Russian texts. The unique section is the one in which the author has endeavoured to formulate rules of procedure for translating.

MARINESCU, M., and APOSTOL, P. 621.395.623.7

Difuzoare electrodinamice (Electro-dynamic loudspeakers)

Bucharest: Editura Academiei Republicii Populare Romine, 1957. pp. 199. 21 × 15·5cm. 11s. approx.

A study of the theory and construction of electro-dynamic loudspeakers and the problem of broadening the frequency response.

MARTON, L. (*Editor*) 621.38

Advances in electronics and electron physics—Vol. 6*

New York and London: Academic Press, 1959. pp. xi, 523. 23·5 × 15·5cm. £5 7s. 6d.

An annual volume containing selected critical and integrated reviews in the field of physical electronics including photoemission, semiconductors, automatic data-processing, operational amplifiers, and radio telemetering.

MILLS, G., and STANDINGFORD, O. 651

Office organization and method. 2nd edition*

London: Pitman, 1959. pp. viii, 360. 22 × 14cm. 22s. 6d.

This practical work surveys the entire field including organization and control, accounting and general services, machinery and equipment, accommodation, furniture, personnel policy, and committee procedure. This new edition includes chapters on electronic computers and production control.

PETTIT, J. M. 621.38

Electronic switching, timing and pulse circuits*

New York and London: McGraw-Hill, 1959. pp. xiii, 267. 24 × 15·5cm. £2 18s.

This is for senior college students. It deals with a basic type of analysis of circuits using the static characteristics of the valves and transistors employed during direct subperiods of the operating cycle. The process is explained by the extensive use of numerical examples. This book will be reviewed in a future issue.

REZA, F. M., and SEELY, S. 538.551

Modern network analysis*

New York and London: McGraw-Hill, 1959. pp. xi, 373. 24 × 16cm. £3 17s. 6d.

This intermediate-level book examines the fundamentals of network analysis, applications to two-port networks, filters, transmission lines and transient response. It will be reviewed in a future issue.

Library accessions (continued)

SEMAT, H., and WHITE, H. E. 539

Atomic age physics*

New York: Rinehart, 1959. pp. vii, 230. 20 × 13·5cm. 16s.

Based on a series of television lectures given in the United States and intended for the layman and the non-specialist, it deals first with the behaviour of atomic particles and then with the nucleus.

SINGER, J. R. 621.375.9

Masers*

New York: John Wiley. London: Chapman and Hall, 1959. pp. xi, 147. 23 × 14·5cm. £2 12s.

Approaches the subject from both the classical and the quantum-mechanical points of view. Considers gas masers, electron paramagnetic resonance, two-level solid-state and three-level cavity masers and travelling-wave masers. This book is reviewed on p. 121.

SMITH, C. V. L. 518.5

Electronic digital computers*

New York and London: McGraw-Hill, 1959. pp. ix, 443. 24 × 16cm. £4 13s.

It is not intended to be an advanced work and aims at giving a general picture of the basic principles and the way in which the various circuits and devices function. Reviewed in October 1959 *Journal*, p. 606.

STARR, A. T. 621.38

Electronics. 2nd edition

London: Pitman, 1959. pp. viii, 429. 23 × 14cm. 35s.

Covers the syllabus of electronics for the London B.Sc.(Eng.) degree. Emphasizes the physical and mathematical aspects of the subject, such as the modern theory of metals, semiconductors, the Laplace transform, and Heaviside's operational calculus.

WHITROW, M. (*Editor*) 014 : 043

Index to theses accepted for higher degrees in the universities of Great Britain and Ireland—Vol. 7, 1956–57

London: Aslib, 1959. pp. xii, 177. 24·5 × 15cm. 25s.

WILSON, W. K. 534.1

Vibration engineering; a practical treatise on the balancing of engines, mechanical vibration, and vibration isolation*

London: Griffin, 1959. pp. xii, 292. 25 × 17cm. £4 10s.

Discusses the fundamentals of torsional vibration, engine balancing, vibration isolation, and the resolution of problems in aeronautical, automobile, marine and stationary equipment.

ZIEL, A. van der 621.315.59

Fluctuation phenomena in semi-conductors*

London: Butterworth, 1959. pp. viii, 168. 22 × 14·5cm. 35s.

A survey of theoretical and experimental work on fluctuation phenomena. The effects, generally known as thermal, flicker and shot noise, are considered under the heads: generation-recombination noise, caused by spontaneous fluctuations in the generation rates, recombination rates, trapping rates, etc. of the carriers; diffusion noise giving rise to fluctuations in the carrier density; and modulation noise. Reviewed in September 1959 *Journal*, p. 543.

OTHER PUBLICATIONS

AUSSCHUSS FÜR FUNKORTUNG

Radio-navigation systems for aviation and maritime use; a comparative study. Joint report by the Ausschuss für Funkortung and the Nachrichtentechnische Gesellschaft

Düsseldorf: Ausschuss für Funkortung, 1959. pp. 185. 29 × 21cm. DM6

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Automatic control in Soviet industry. A report of a visit to the Soviet Union, May 1959

London: Department of Scientific and Industrial Research, 1959. pp. 64. 33 × 20cm. n.p.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

An introduction to waveguides and microwave systems by C. F. Floyd. Paper No. 214

London: Institution of Post Office Electrical Engineers, 1959. pp. 23. 27 × 21·5cm. 2s. 6d.

UNITED NATIONS

Proceedings of the second United Nations international conference on the peaceful uses of atomic energy, held in Geneva, 1st–13th September 1958. Vol. 7—Reactor technology

Geneva: United Nations, 1958. pp. x, 843. 28·5 × 22cm. £7

District Meetings

ARRANGEMENTS for District Meetings in March 1960 other than in the area of a local Centre

March 1960

OXFORD (at the Southern Electricity Board Service Centre, 37 George Street at 7 p.m.)

9 *Wednesday* H. E. FRANCIS 'Automation of the national telephone system'

READING (at the George Hotel, King Street at 7.15 p.m.)

14 *Monday* R. H. GOLDE, PH.D., D.SC.(ENG.) 'The protection of high-voltage systems from lightning faults'

British Nuclear Energy Conference

DETAILS of three forthcoming meetings of the British Nuclear Energy Conference are given below. Tickets of admission are not required

1960

MARCH 2 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Informal discussion on THE ROLE OF FORMAL EDUCATION AND TRAINING IN NUCLEAR-POWER DEVELOPMENT

MARCH 9 *Wednesday* (5.30 p.m.)

Sponsoring society: The Institute of Fuel
Place of meeting: The Institution of Civil Engineers, Great George Street, London S.W.1

NUCLEAR POWER FOR MARINE PROPULSION J. E. Richards

MARCH 30 *Wednesday* (10.30 a.m.)

Sponsoring society: The Institute of Metals
Place of meeting: Hoare Memorial Hall, Church House, Westminster, London S.W.1

SPRING MEETING

Discussion on the paper VOLUME INCREASES IN FISSILE MATERIALS ON NEUTRON IRRADIATION AND THE EFFECTS OF THERMAL FLUCTUATIONS G. W. Greenwood

Members wishing to contribute to the discussion are asked to write to the Secretary of The Institute of Metals, 17 Belgrave Square, London S.W.1, as soon as possible

The following elections and transfers approved by the Council are effective from the 7th January 1960

ELECTIONS

Graduates

ARCHIBALD, Robert
ARMSTRONG, Malcolm Sneddon
BALAAM, Henry James
BALLAN, Mohamed Kassem, B.SC.
BARCLAY, Mitchell, B.SC.
BARRAULT, Michel Raymond, B.ENG.
BEDFORD, Ronald Alfred
BERMAN, Lawrence John
BODEDE, Alfred Adebayo, B.SC.
BODEN, Samuel John Oliver, B.SC.
BONE, Anthony Gerard, DIP.TECH. (ENG.)
BROWNLEE, Graham
BUCKLEY, Alexander James
CANDLIN, David Richard, B.A.
CARMICHAEL, Malcolm Robert
CARTAR, Theodore Fitzroy, B.SC.
CHAMBERS, Ralph George William
CHURCHER, John Henry James
CLARKE, Terence Langford, B.SC.(ENG.)
CLEGG, Ivan
COLE, David Hugh
COLLING, Brian
CONNLEY, Brian, B.A.
DELI, George Charles, B.SC.(ENG.)
ELLISON, David Francis, B.E.
EVANS, Anthony Herbert, B.SC.TECH.
EVANS, Samuel Brian
FRITH, Richard
GEORGE, Ronald Percival
GIBSON, Alan
GRAY, Robert Wood
GREEN, John Edwin
GRIFFIN, Brian
HALLETT, James Edward
HANLEY, Albert Edward
HARDING, Rex Ashton
HARRIS, Douglas John
HARVEY, Leonard James
HELY, Michael Hamilton McMath, B.A.
HICKS, John David Glyn, B.SC.
HILL, Dennis, B.SC.
HOWSON, William
JOHNSON, George Alan
JOICE, Harold Lishman
JONES, Cecil Brychan
JONES, Terence Walter
KING, Alan Richard, B.SC.(ENG.)
LAMB, Geoffrey
LEVITT, Harry, B.SC.(ENG.)
LLOYD, Gordon John, B.SC.
MACPHERSON, Ronald Ian Campbell, B.SC.(ENG.)
MAGIMAY, Marie Francis, B.E.
MALKA, Carlos Saul
MANLEY, David Michael John Picton, PH.D., B.SC.
MAXWELL, Lt. Robin Carlton, B.A., R.N.
MEWES, Kenneth George Matthew
MEWETT, Graham John
MILTON, Frederick William Alexander
MOTTERSHEAD, Donald
NETTLE, David William
NIELD, Brian
OKARU, Paul Newton, B.SC., B.SC.(ENG.)
OWEN, Arthur Ronald
PADFIELD, Anthony David Doel, B.A.
POOLE, Darrell Owen, B.SC.(ENG.)
RANFORD, David Kilgour, B.E.
RANKIN, John Robert
REEVES, Denis Neville, B.SC.(ENG.)
ROBERTS, Frederick Antony, B.ENG.
SARGENT, Trevor Linford
SARJEANT, Arthur Augustus
SOAR, Aloysius, B.SC.(ENG.)
SPIERS, Frederick Morris, B.SC.(ENG)
SPRING, Anthony John, B.SC.(ENG.)
STEWART, Donald David
STILL, William Abel
STOREY, Raymond
TAYLOR, Brian Redmayne, B.SC.
TAYLOR, Eric
THOMAS, Allen John, DIP.TECH.(ENG.)
THRELKELD, Frederick Peter
TIZZARD, Ronald Frederick
TOWNSEND, Graham Edward
TURNER, Philip
UNDERWOOD, John
UTKU, Ruhi, M.SC.
WALKER, John Harry
WEBSTER, Ronald
WHITE ATKINS, Lt. Edward Blake, B.A., R.N.
WILKINSON, Frank, B.SC., PH.D.
WILLIAMS, Mervyn Geldart
WILLIAMSON, Keith Hudson, B.SC.
YUSOFF, Nik Mohamed Bin

Students

ABU-BAKR, Mohammed Zahir
ADDO, John Motey
AMIES, Gerald Edward
ANDREWS, Lancelot Galsgaard
ANGELL, Ian Roger Jarratt
ASHBY, Barry
ATKINSON, Edmund Peter Taylor, B.SC.
BALDWIN, Alan Thomas
BAREHAM, Robert Charles
BARTLETT, Paul Davie
BATEMAN, Robert Frank
BISHUI, Phanindra Nath
BLAYDES, Barry Paul
BLENCOWE, Keith
BLYTHIN, Peter Samuel
BOND, Malcolm
BOOTHMAN, Alan James
BOOTHMAN, Martin
BOWDEN, Richard Scott Montgomery
BOWIE, John Edward
BOWLES, John Frederick William
BRACE, John Lawrence
BRAUDE, Bernard, B.SC.
BRIDGES, William James, B.SC.
BRIERLEY, Anthony Herman
BROADHURST, Derek
BROWN, John, B.SC.
BROWN, Philip Jeremy
BUCKLE, Jeffrey
BURCHILL, Brian Kenneth
BURNETT, Keith Johnson
CAREY, Patrick Lawrence
CARPENTER, Norman
CARTER, David Arthur
CARTER, Eric Vance
CARVALHO, Viviano Francisco
CASSIDY, Bernard Francis Desmond
CHANCE, James Percy
CHANDRASENA, Appukuttiaratchige Don
CHAPMAN, John Frederick
CLARKE, Peter Terence
COLGAN, John Francis
COLPUS, John Russell
COOKE, Norman
COOKE, Roger Ernest
COOKSON, Leslie
COOMBS, Brian Munro
COPE, Brian John Bailye, B.SC.
COPLEY, Douglas Henry
COTTER, Lawrence Michael
COTTON, Donald Julian

Students (continued)

CRAIG, Cyril Noel
CRAIG, Timothy Knaggs
CRAMMOND, Douglas Alexander George
CRAMMOND, Jeremy John, B.SC.(ENG.)
CREE, Ronald George
CROSS, Bryan
CROSS, Geoffrey
CROUCH, Raymond Frederick
CROUCH, William Jewitt
DAKIN, George James
DAVIES, Islwyn
DAVIES, Philip Ronald
DAVIS, John Richard Cameron
DAVISON, George Howard, B.SC.
D'CRUZ, Lambert Edmund
DENNEY, Ian Alexander
DENNIS, James
DE SILVA, Hirimutugodage Kenneth Maurice
DHALLA, Mohamed Husein
DI GLERIA, Peter Anton
DILLICAR, Colin Richard
DIRATZOUIAN, Ohannes Yervant
DONOVAN, John Reeve, B.SC.(ENG.)
DOWN, Bryan
DOYLE, Norman Patrick
DUNBAR, Kenneth Alexander
DUNMORE, Edward John
EAST, Peter William
EASTERLING, Brian Anthony, B.SC.
EDWARDS, John Charles
EDWARDS, Michael Geoffrey, B.SC.
ELDERTON, Merrick Thomas
ELLIS, Richard John Godwin
EWENS, Stuart Christopher, B.SC.
FAIRBROTHER, Leslie Ronald
FALCONER, John
FARNCOMBE, Michael Ronald
FELLOWS, Kenneth Gordon
FEREDAY, Michael Standley
FISH, Michael Edward
FORDER, Roy Arthur
FOURIE, Eugene, B.SC., B.ENG.
FOWLE, Edward Frederick
FRASER, George Lewis
GARDNER, Frederick James
GARDNER, John Leslie
GAY, Michael John
GEDGE, John Lewis
GEERE, Ronald Durston
GILLETT, Michael John
GLANVILLE, Rodney Francis
GLAVE, Trevor John
GLEAVES, Casson Dawson, B.SC.
GODDEN, John
GORDON, Cormac Noel
GRANT, Stuart Bruce
GUNDLACH, Alan Michael, B.SC.
GUPPY, Christopher John
HAIGH, Brian
HAIGH, Stuart
HALL, Edgar Ronald, B.SC.
HARRIS, John William
HARRISON, Peter
HASLAM, Harry Myles
HAWRYSZKIEWYCZ, Igor Titus
HAYES, Roy
HAYNES, Kenneth, B.SC.TECH.
HAYTHORNTHWAITE, Sub-Lt. Alfred Ian Carlstrom, R.N.
HEATON, John Frederick
HENWOOD, Timothy
HERRING, Gordon
HICK, Michael Alfred Sampson
HICKS, John Brian
HIGNETT, Robert James
HILES, Christopher
HILL, Colin Nicholson
HILL, David George
HILL, Michael Dawes
HILLIER, William Edward
HINES, John Richard
HINTON, Norman George
HO, Shao Meng
HOLDEN, Thomas Leonard
HOLLAND, John
HOOK, Granville Ernest Edward
HOSKYNS, Richard Francis
HOWELLS, Roderick Brian
ILLINGWORTH, James
ISON, Peter Reginald Edgar
JAMANI, Nooraly Hassanali
JAMES, Christopher John
JENNINGS, Peter Charles
JEWSON, Frank
JOHNS, Bernard Thomas, B.SC.
JOHNS, Brian
JOHNSON, Brian Keith Alexander
JONES, John Michael
JONES, John Winston
JONES, Roger Edward
KEMP, Frederick Benjamin
KEMP, Paul Barradell
KENDALL, Brian Keith
KENNEDY, Ian Anderson Bullard
KERBY, John Leslie, B.A.
KHAN, Shafqat Raza, B.SC.
KING, Michael Charles Harry
KNIGHT, David Charles
KUBBA, Om Parkash
LAUDER, George
LEAR, David Edward Arthur
LEPPARD, John William
LEVER, Philip William Arnold
LIGHTFOOT, Norman Wilfred John
LIPMAN, Michael Maximillian
LOCK, Anthony David
LOCKETT, Anthony David
LOH, Peng-Yuen, A.H.-W.C.
LONGMAN, George Joseph
LUCAS, Michael Edward
LUCKHURST, Barry John
MCDOWELL, William Thomas Raymond
MCGRATH, Andrew Henry
MCTIGHE, Anthony Norman
MANNING, David Brian
MANSON, Alan Lindsay
MARRIOTT, Trevor
MARTIN, Anthony John
MARTIN, Roger
MATON, Arthur Brian
MATTHEWS, Alan William
MATTHEWS, Colin David
MATTHEWS, William Patrick
MEECH, John Norman
MEHRTENS, David Henry, B.SC.
MILDOON, John
MIRES, Arthur John
MITTING, Kevin David
MOORE, John Colin
MOORE, William Neville
MORRISON, Gordon Victor
MOSELY, Antony Perceval, B.SC.
MUBIRU, Stone Moses
MUNIDASA, Pilane Liyanage, B.SC.
MURPHY, John Martin
MURRAY, John Brian
MUSGRAVE, Michael John
NAGENDRA, Subramaniam
NATUSCH, Ian Henry
NAYLOR, Kenneth Adrian
NOAKES, Leslie Gerald
NORTH, David William
NOTT, Brian Peter
O'FARRELL, John Stephen, B.SC.
OLD, Geoffrey Ernest
OLIVER, John Charles Richard
OSBORNE, Peter David
O'SHEA, Alfred Finbarr Joseph
OVERTON, David
OWEN, David
OWEN, Elfed Rhys
PADDON, Leonard Byron
PARKER, Brian
PARKER, John William
PARKER, Robert Brian
PAYNE, Barry John
PECK, Reginald

Elections and transfers (continued)

Students (continued)

PEGRUM, David Noel Methley
PENERY, Michael Thomas
PENKETH, John Reginald
PERERA, Ranwalage Felix, B.SC.
PERKINS, Robert Anthony
PERKS, Michael John
PETTIT, Patrick, B.A.
PHILLIPS, Barry John
PIGOTT, Peter Malcolm
PINGSTONE, Adrian Ralph
POFFLEY, David Arthur
POLLARD, Colin
POTT, John Benjamin
POWNALL, Robert Bernard
PRINCE, Martin Armitage
PUGH, Martin Harold
RADHAKRISHNANI, Girdharkal Balram, B.E.
RAHIM, Mohamed Aziz Sherali
REILLY, Robert Edward
REMNANT, Ronald Henry
RICHARDSON, Kenneth Charles Smart
RICHARDSON, Michael Anthony
RILEY, John Netherwood, B.A.
ROBERTS, John Stanley
ROBERTSON, John William
RODWELL, Raymond George
ROENGPITHYA, Viphandh
ROGERS, Terry Gordon, B.SC.
ROOKS, Leslie David
ROSCOE, Alan William
ROWE, Brian Anthony
RUFFLE, Alan Keith
RUPAREL, Jitendra Vrajlall
SACK, Martin Glazebrook, B.A.
SANDELL, William Frederick Arthur
SATHIAMOORTHY, Navaratnam
SAUNDERS, John Raymond
SEALE, David Alexander
SEARWAR, Cosmas Bernard Anthony
SENTANCE, Nigel John
SHACKLETON, David William
SHARMA, Rajinder Kumar
SHARP, David Eric
SHELTON, Lt. Raefe Michael Brunker, R.E.M.E.
SHERBURN, Frank Collinge
SHINGLES, Godfrey Stephen
SHORE, William
SINDEN, Edgar William
SKELTON, Peter John
SKIPPEN, David John Mason
SMETHURST, John Adrian
SMITH, Alfred Keith
SMITH, Andrew Martin
SMITH, Gordon
SMITH, John Arthur George
SMITH, Laurence Sidney
SNOW, Frederick Albert, B.SC.
SPINK, Henry Charles
STALLARD, Robin, B.SC.
STEELE, Brian Frederick
STEVENS, Brian Lawrence
STOKES, Roy MacDonald
STOREY, Brian, B.SC.
STOTT, Peter
STUART, Robert Kennedy, B.A.
SUDBURY, Noel Desmond
SULLY, John Bentinck
SWINDELL, William, B.SC.
TAMM, Peter Henry
TAYLOR, Joseph Barry
THOMAS, Brian Gregory
THOMPSON, John Douglas, B.SC.
TONKS, Eric
TOWNSEND, David Brian
TRAYNOR, Fintan Paul
TRUMAN, Norman Nathan, B.SC.
TRUMPER, Barrington Thomas, B.SC.
URWIN, Leonard Henry
VARMA, Nareshkumar Jaikrishna
VIDLER, Michael Alfred
VINCENT, Dudley Joseph
VIRR, Leonard Edward
WAINWRIGHT, Anthony
WAINWRIGHT, John Roy, B.SC.
WALKER, David John
WALKER, Derek Llewellyn
WALKER, John Richard
WALTER, John Bernard
WARDLE, Terence Newton
WEBB-CORNWALL, Harold
WEST, John Kenneth
WESTLAKE, Paul Sidney
WHEAWELL, Thomas Harold
WHITE, Brian Francis Kenneth
WHITE, Brian Glyn
WHITE, George William
WHITE, Richard Eugene Charlton
WHITELEY, Timothy
WHITMAN, Anthony Gwynn
WIDGER, Glanville Francis Thomas
WIGZELL, James Laborda
WILLIAMS, David Sidney Layley, B.SC.
WILLIAMS, Dennis Ernie
WILLIAMS, Robin
WINROW, Colin Harold
WOLSTENHOLME, John
WOODCOCK, Melvyn Edward
WORRALL, David Leslie
WORTON, Lawrence Vivian
WRIGHT, Alan
WRIGHT, Bryan Peter
WRIGHT, Maurice Henry, B.SC.
WU, Yu-Ngong
YEO, Hock Keng
YORK, John David

TRANSFERS

Student to Graduate

ADAMS, Charles Ernest, B.SC.(ENG.)
ALLGOOD, Arthur Peter, B.SC.(ENG.)
ASPREY, Wilfred Brian
BAKER, John Gilbert Roswell, B.SC.(ENG.)
BARKER, Maurice
BARTON, Gareth Robert, B.SC.
BATTY, Alan Charles, B.SC.(ENG.)
BELL, Roy Malcolm
BILLING, Peter James
BLAKE, Denis Godfrey, B.SC.(ENG.)
BLISS, Eric Morley, B.SC.(ENG.)
BOOTH, Robert, B.SC.
BRADBURY, Michael Vincent, DIP.TECH.(ENG.)
BRADLEY, Colin Roland, DIP.TECH.(ENG.)
BROWN, Michael Edwin, B.SC.(ENG.)
BULLEN, Nigel
BURDEN, Barry Thurlow
BUTLER, David John, DIP.TECH.(ENG.)
BYE, Keith Leslie
CALLIGAN, Kenneth Frederick, B.SC.TECH.
CHALMERS, James Ferguson, B.SC.
CLIFFORD, John Henry, B.SC.
CLUGSTON, Thomas Richard, B.ENG.
COX, Junior Colin, B.E.
CROOCK, Bennie
CROSSINGHAM, Ian Henry, DIP.TECH.(ENG.)
DE'ATH, James John David
DE LA HAYE, Alfred Charles, B.SC.(ENG.)
DI MAMBRO, Peter Henry, B.SC.
DORE, Derek Frederick George, B.SC.(ENG.)
DUFFETT, Derek Dinsdale, B.SC.(ENG.)
EDWARDS, John Ronald, B.SC.(ENG.)
EUNSON, Eric Magnus, B.SC.(ENG.)
EVANS, Brian Edward, B.SC.
EVANS, Deryck, B.SC.
EVERTON, Peter Norman, B.SC.
FLEMING, David Love, B.SC.
FRANGOU, Takis Antonios, B.SC.(ENG.)
GARDNER, Stanley John
GERRY, Raymond William, B.SC.(ENG.)
GLEDSON, Richard Michael, B.SC.
GLENNIE, William Sebastian, B.SC.(ENG.)
GUPTA, Krishna Avtar, B.E., B.SC.(ENG.)

Student to Graduate (continued)

GUPTA, Prem Prakash, PH.D., B.SC.
HALL, Brian
HARDING, Robert Harold
HITCHCOX, Michael Edward, B.SC.(ENG.)
IBALL, John Elwyn
JACKSON, David, B.SC.
JACKSON, William Barry, B.SC.
JAMES, Brian Frederick, B.SC.(ENG.)
JOHNS, Antony, B.A.
JOHNSON, Roger Christopher Howard, B.SC.(ENG.)
KANTARIZIS, Emmanuel, B.SC.(ENG.)
KING, Alan Charles
LANGLEY, Ivan John, B.SC.(ENG.)
LATHAM, Peter Richard Ernest, B.SC.(ENG.)
LE CLUE, David, B.SC.(ENG.)
LOCKHART, Alexander John, A.R.C.S.T.
MADDAFORD, Alan Keith, B.SC.
MONTGOMERY, George Richardson, B.SC.
NEALE, Douglas Frederick, B.SC.
NEWEY, David Alan
NG, Liew Hing, B.A.
NORTON, John, B.SC.
OLDHAM, Derek Thomas, B.SC.
PAGE, Peter Bernard
PARK, Michael Frederick, B.ENG.
PASMORE, Tom, B.SC.
POUND, Graham Dudley, B.SC.(ENG.)
RENDLE, Richard Garth, B.SC.
REID, James, B.SC.
ROBINSON, Frank
RODGERS, David Henry, B.SC.
ROGERS, Leslie Richard, DIP.TECH.(ENG.)
ROPER, Hugh
ROTHWELL, Ronald
SEE THO, Kok Hong, B.SC.(ENG.)
SCOTT, Michael
SPARROW, John Osborne, B.SC.
STACEY, Peter James
STERN, Brian John Charles
STORKEY, Robert, B.SC.(ENG.)
SYMEONIDES, George, B.SC.(ENG.)
TAYLOR, Derek John, B.SC.
WEBER-BROWN, Nicholas Ellson, B.A.
WEIL-MALHERBE, Claude Michael, B.SC.
WELLBY, John Patrick, DIP.TECH.(ENG.)
WHEELDON, Anthony, DIP.TECH.(ENG.)
WILTSHIRE, Trevor John, D.L.C.
WOLFE, Lionel John, B.SC.(ENG.)
WRIGHT, Geoffrey John

The following elections and transfers approved by the Council are effective from the 1st February 1960

ELECTIONS

Associate Members

ACTON, Eric William Vickers, B.SC., M.SC.
ARCHENHOLD, Henry
BATTYE, Edwin Armitage
BEERE, Cmdr. Graeme Maunsell, B.SC., R.N.Z.N.
HAFFNER, Victor Adetunji
MILLS, Bernard Douglas, B.E., B.SC.
NUTBEAN, William Ivor
TOWNLEY, Charles Henry Angus, M.A.

Associates

CRAWT, Maurice James
INGRAM, Kenneth Wigston
MILLS, James Irvine

TRANSFERS

Associate Member to Member

ALLAN, Francis William
BARKER, Ronald Hugh
BASSETT, Joseph Alfred
BROOKE, Edric Raymond
GALBRAITH, Col. Reginald Arthur Harvey, O.B.E., B.A.SC., M.A.
HARDAKER, Ernest Victor, M.C., B.SC.
HARVEY, Philip Henry
HATHAWAY, Richard
LESLIE, William Henderson Paterson, B.SC.
LOTT, Alan Edwin
MARE, Arthur John
MAYOR, Albert
MORLEY, John Baillie, B.SC.TECH.
PRITCHARD, John Neville Hilton
PUTNAM, Adolph Rupert, B.E.E.
ZANDSTRA, Klaas Anne

Associate to Associate Member

MACKAY, Victor Peterson
SMITH, John Frederick

Graduate to Associate Member

AKASS, Capt. John Leslie, B.A., R.E.M.E.
BARCLAY, Deryk Neville
BATCH, Bertie Alfred, B.SC.(ENG.)
BLACKBURN, James Alfred
BLYTHE, Gordon
CHAPMAN, Gerald Anthony
CLEE, Harry
COUSIN, David Robert, B.SC.(ENG.)
CROWTHER, Walter Hallewell
GRIFFITHS, Robert Goodger, B.SC.
HICKERTON, Thomas George
JACKSON, Ronald Albert
JOHNSON, Donald Archibald Harvey, M.SC.
LLOYD, Brian Edmund
LUMLEY, Richard Robert
PARR, David John, B.SC.(ENG.)
PARSONS, Lionel Charles, B.E.
PERRINS, Vernon Thomas
RICHARD, Malcolm James, B.SC.
RILEY, James Hubert, B.SC.(ENG.)
ROPER, Roy Derek
SHUFFLETON, Wallace Henry
THOMPSON, Robert John
TOMIC, Ivan Marijan, ING.
WATSON, Benjamin
WHITTLE, David John, M.A.
WILKINSON, Edward Charles Terence
WORTHINGTON, Gordon, B.SC.TECH.
WRIGHT, Donald Richard
WYLIE, James Arthur
ZAWELS, Jakob, B.SC.(ENG.), M.SC PH.D.

Student to Associate Member

SUTHERLAND, Alistair Campbell, B.SC.(ENG.)

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card.

February 1960

M **16** *Tuesday* R. E. CLARK will open a discussion on 'Soviet control-engineering progress'†

17 *Wednesday* PROF. M. G. SAY, PH.D., M.SC., F.R.S.E. The Faraday Lecture: 'Electrical machines'‡ (at Central Hall, Westminster, London S.W.1, at 6 p.m.; admission by ticket available on receipt of a stamped addressed envelope)

U **18** *Thursday* B. E. A. VIGERS, M.A., *and* R. O. FLETCHER, B.SC. 'Electricity in the manufacture of hydrogen peroxide' (paper 3196U) *synopsis:* January 1960

I **22** *Monday* L. ROTHERHAM, M.SC., will open a discussion on 'Are we making the best use of research resources?'*

ED **23** *Tuesday* PROF. M. W. HUMPHREY DAVIES, M.SC., will open a discussion on 'Courses for electrical technicians'* (at 6 p.m., tea at 5.30 p.m.)

E **24** *Wednesday* PROF. A. L. CULLEN, PH.D., B.SC.(ENG.). Lecture on 'Applications of microwaves'†

25 *Thursday* Annual Dinner (at Grosvenor House, Park Lane, London W.1, at 7 for 7.30 p.m.)

March 1960

M **1** *Tuesday* T. KILBURN, M.A., PH.D., D.SC. Lecture on 'Digital-computer developments at Manchester University'†. Supported by these papers: T. KILBURN, M.A., PH.D., D.SC., *and* R. L. GRIMSDALE, M.SC., PH.D. 'Digital-computer store with very short read time' (paper 3178M) *synopsis:* January 1960; G. R. HOFFMAN, PH.D., B.SC., D. H. SMITH, M.SC., *and* D. C. JEFFREYS, M.SC. 'High-speed light output signals from electroluminescent storage systems' (paper 3217M) *synopsis:* see p. 113. Together with a contribution by D. B. G. EDWARDS, PH.D., M.SC., M. J. LANIGAN, M.SC., *and* T. KILBURN, M.A., PH.D., D.SC. 'Ferrite magnetic-core memory systems with rapid cycle times'†

O **3** *Thursday* SIR HUGH BEAVER, K.B.E., LL.D., D.ECON.SC. Sixth Graham Clark Lecture. 'The engineer and civilization'‡ (joint meeting with The Institutions of Civil and of Mechanical Engineers)

MED **4** *Friday* A. SMALE, B.SC., *and* S. N. POCOCK will open a discussion on 'Direct-writing oscillographs'* (at 6 p.m., tea at 5.30 p.m.)

E **7** *Monday* P. N. BUTCHER, PH.D., B.SC. 'Introduction to the theory of masers with particular reference to the travelling-wave maser' (paper 3220E) *synopsis:* see p. 113

S **9** *Wednesday* B. F. SALVAGE, B.SC.(ENG.), PH.D., *and* J. A. M. GIBBONS, B.SC. 'Impulse strength of impregnated-paper dielectrics as used in h.v. cables' (paper 3143S) *synopsis:* December 1959

U **10** *Thursday* J. P. McBREEN 'Some considerations in the application of power rectifiers and convertors' (paper 3215U) *synopsis:* see p. 113

EM **11** *Friday* Joint dinner-dance (at the Café Royal, London, at 7 for 7.30 p.m.)

I **14** *Monday* K. E. GREENE will open a discussion on 'Should engineers be encouraged to take up administrative positions early in their careers?'* (joint meeting with the London Graduate and Student Section at 6 p.m., tea at 5.30 p.m.)

M **15** *Tuesday* I. C. HUTCHEON, M.A., *and* D. SUMMERS 'Low-drift transistor chopper-type d.c. amplifier with high gain and large dynamic range' (paper 3227M) *synopsis:* see p. 113

S **16** *Wednesday* D. H. GRINDELL, PH.D., B.SC.(ENG.) 'An electrostatic dust monitor' (paper 3184S) *synopsis:* January 1960

E **23** *Wednesday* G. MILLINGTON, M.A., B.SC. Lecture on 'The challenge of the propagation medium to the radio engineer'†

ED **29** *Tuesday* G. F. FREEMAN, M.SC.(ENG.) will open a discussion on 'The place of illumination in electrical engineering'* (at 6 p.m., tea at 5.30 p.m.)

S **30** *Wednesday* Section dinner-dance (at the Connaught Rooms, London, at 7 for 7.30 p.m.)

O **31** *Thursday* PROF. C. F. POWELL, M.A., PH.D., SC.D., F.R.S. 51st Kelvin Lecture. 'Cosmic radiation'‡

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (FEBRUARY 1960)

SIR WILLIS JACKSON, D.SC., F.R.S. **Inaugural Address** *January 1960*

J. R. MORTLOCK, B.SC.(ENG.), PH.D. **Supply Section: Chairman's Address** *January 1960*

T. E. HOUGHTON, M.ENG. **Utilization Section: Chairman's Address** *January 1960*

Centre and Sub-Centre Chairmen's Addresses

Discussion on **Results of full-scale stability tests on the British 132 kV Grid system** and **Organization for large-scale Grid system tests** before the North Staffordshire Sub-Centre, the North-Western Centre, the South-West Scotland Sub-Centre and the Western Centre

COLIN ADAMSON, M.SC.(ENG.), *and* E. A. TALKHAN, B.SC., PH.D. PAPER 3137M **Selection of relaying quantities for differential feeder protection** *February 1960*

PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.), *and* J. C. BEAL, B.SC.(ENG.). PAPER 3136M **An experimental impedance relay using the Hall effect in a semiconductor** *February 1960*

R. N. SUDAN, D.I.I.SC., PH.D., V. N. MANOHAR, B.E., M.SC.(ENG.), *and* E. ADKINS, M.A., D.SC.(ENG.). PAPER 3151S **The measurement of transient torque and load angle in model synchronous machines** *January 1960*

D. B. MEHTA, B.E., M.SC.(ENG.), *and* B. ADKINS, M.A., D.SC.(ENG.). PAPER 3160S **Transient torque and load angle of a synchronous generator following several types of system disturbance** *January 1960*

J. W. SKINNER, B.SC.(ENG.). PAPER 3194M **The measurement basis of electricity supply metering** *February 1960*

PROF. J. C. PRESCOTT, D.ENG., *and* A. K. EL-KHARASHI, B.SC., PH.D. PAPER 3179S **The performance of displacement governors under steady-state conditions** *February 1960*

Discussion on **Supply-voltage and current variations produced by a 60-ton 3-phase electric arc furnace** before the Western Centre, the South-West Scotland Sub-Centre and the South Midland Supply and Utilization Group

Discussion on **Communication, indication, and telemetering for the British Grid** before the North-Eastern Centre, the South Midland Centre, the South-East Scotland Sub-Centre, the North Midland Centre and the North-Western Supply Group

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (JANUARY 1960)

See the Journal for January 1960, p. 51

PART C. MONOGRAPHS (SEPTEMBER 1959)

See the Journal for September 1959, p. 557

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 19TH JANUARY 1960

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	905	9448	19	3
£2 to <£5	2209	6090	14	7
under £2	27200	14290	3	7
		£45696	0	5

HONOURS AND DISTINCTIONS

THE names of these members of The Institution were included in the list of New Year Honours and Distinctions conferred by Her Majesty:

BARON

Nelson, Sir George H., BART. (*Past-President*)

COMMANDER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Davies, L. J., M.A., B.SC. (*Member*)
Green, S., B.SC. (*Member*)
Nicholas, A. J., O.B.E. (*Member*)
Pattison, Capt. G. R. B., B.SC. (*Associate Member*)
Ramsay, H. T., M.SC.(ENG.) (*Member*)
Sharples, J., B.SC.(ENG.) (*Member*)
Stubbs, Maj. W., M.C. (*Member*)
Turner, Air Comm. C. A., O.B.E., R.N.Z.A.F. (*Associate Member*)
Williams, Frank, B.SC. (*Member*)
Zweigbergk, Brig. C. A., M.C., M.SC.TECH. (*Member*)

OFFICER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Brewin, F. J. (*Associate Member*)
Cole, A. W. H. (*Associate Member*)
Douglas, T. K. A., B.SC. (*Member*)
Pout, H. W., B.SC.(ENG.) (*Associate Member*)
Timberlake, E. J. (*Associate*)
Whittaker, J. E., B.SC.(ENG.) (*Member*)

MEMBER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Atkinson, William, D.C.M., M.M., B.E.M. (*Associate Member*)
Draper, A., B.SC.(ENG.) (*Member*)
Marshall, W. J. (*Associate Member*)
Payne, N. G. (*Associate Member*)

NOMINATIONS

GREAT BRITAIN–U.S.S.R. ASSOCIATION

THE Council have nominated Sir Josiah Eccles, C.B.E., D.SC., PAST-PRESIDENT, as their representative on the Council of the above association.

COLLEGE OF AERONAUTICS, CRANFIELD, GOVERNING BODY

The Council have nominated Mr. S. E. Goodall, M.SC.(ENG.), PAST-PRESIDENT, as their representative on the above governing body to fill the vacancy caused by the death of Mr. T. E. Goldup.

LANCHESTER COLLEGE OF TECHNOLOGY, COVENTRY, ELECTRICAL ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. C. F. Freeman, B.SC.(ENG.), MEMBER, and Dr. D. N. Truscott, O.B.E., B.SC.(ENG.), MEMBER, as their representatives on the above committee.

LANCHESTER COLLEGE OF TECHNOLOGY, COVENTRY, AERONAUTICAL ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. R. T. Coe, M.A., M.SC.TECH., MEMBER, as their representative on the above committee.

FINSBURY TECHNICAL COLLEGE, ADVISORY COMMITTEE

The Council have nominated Mr. F. C. Widdis, B.SC.(ENG.), ASSOCIATE MEMBER, as their representative on the above committee.

JOINT OVERSEA ACTIVITIES COMMITTEE OF THE THREE ENGINEERING INSTITUTIONS

The Council have nominated Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC., VICE-PRESIDENT, Mr. S. L. M. Barlow, MEMBER, and Mr. C. O. Boyse, B.SC.(ENG.), MEMBER, as their representatives on the above committee.

JOINT COMMITTEE ON THE APPLICATIONS OF ELECTRICITY IN AIRCRAFT

ON the recommendation of the Utilization Section Committee, the Council of The Institution, acting jointly with the Council of The Royal Aeronautical Society, have set up a Joint Committee on the Applications of Electricity in Aircraft, the constitution being as follows:

Representing The Royal Aeronautical Society
A. J. Barrett, M.SC.AE., B.SC.(ENG.), A.F.R.AE.S.
A. J. Cope, A.F.R.AE.S.
J. F. Lewis, B.SC.(ENG.), M.I.E.E.
E. Lloyd, B.SC.(ENG.), A.F.R.AE.S., A.M.I.E.E.
W. H. McKinlay, B.SC., A.F.R.AE.S.
R. H. Woodall, F.R.AE.S., M.I.E.E.
H. Zeffert, A.F.R.AE.S.

Representing The Institution of Electrical Engineers
P. J. Daglish, B.SC., A.F.R.AE.S., M.I.E.E.
D. C. Flack, B.SC.(ENG.), PH.D., A.M.I.E.E.
Group-Capt. D. W. Rowson, B.SC.(ENG.), A.M.I.E.E., R.A.F.

R. Hilton, M.ENG., A.M.I.E.E.
H. F. Innocent, A.M.I.E.E. (also representing the Air Ministry)
Prof. G. A. Whitfield, B.SC., F.R.AE.S., A.M.I.E.E.

The terms of reference of the Joint Committee are as follows:

(a) To promote the holding of joint meetings to read papers on, and to discuss, matters of common interest to The Royal Aeronautical Society and The Institution of Electrical Engineers

(b) To prepare for submission to the Council of The Royal Aeronautical Society and the Council of The Institution of Electrical Engineers recommendations for good practice in the design and installation of aircraft electrical equipment.

50 YEARS OF MEMBERSHIP

THE Council take much pleasure in placing on record the completion of 50 years of membership of The Institution by the members whose names appear below; they first became associated with The Institution in the year 1910.

Aikman, A. N., B.SC.(ENG.)
Barnard, L. E., B.SC.(ENG.)
Behrens, E. A.
Bowyer, G.
Brearley, C. A., B.SC.(ENG.)
Burge, W. S.
Button, C. F.
Buyers, C. S.
Buzza, P. H.
Carden, Lt.-Col. E. D., O.B.E., R.E.
Carey-Thomas, Lt.-Col. H. C., B.A., R.SIGNALS
Chalmers, J. W. P.
Churcher, B. A. G., M.SC.
Clark, H., B.SC.
Collett, T. A.
Cranston, W. M.
Crowcroft, H. E.
Davies, G. F.
Davies, P. T.
Dent, L. B.
Edward, G. W.
Eley, H. J.
Elliott, J. W., B.SC.
Emtage, E. L. M.
Epton, A. W.
Fry, R. F.
Gomes, J. V. M.
Grant, E. G.
Hackney, S. C.
Hart, A. B., O.B.E.
Hatch, W. A., M.B.E.
Hughes, E., D.SC.(ENG.), PH.D.
Ingram, G.
James, R. N.
Johnson, R.
Kapp, Prof. R. O., B.SC.
McCall, G. W.
Mack, R. A., B.SC.(ENG.)
Matthewman, Prof. T. H., O.B.E.
Maxwell, Lt.-Col. K. G., M.C.
Neill, D. T.
Newman, A. J.
Nottage, H. F.
Orloff, Maj. E., M.B.E., R.E.
Peattie, J. D., C.B.E., B.SC.
Pensabene-Perez, N.
Perryman, N. J.
Phillips, C. H.
Plowman, A. S.
Pocock, L. C., M.SC.
Pradhan, B. B., M.SC.TECH.
Record, O. L.
Richards, W. J.
Richardson, G. W.
Roberts, L.
Roberts, R. J.
Robinson, B. A.
Rowell, J. P.
Rudd, S., B.SC.(ENG.)
Rushton, A., M.SC.
Russell, W. E.
Sharp, L. H.
Skelton, H.
Spencer, W. G., M.SC.TECH.
Spendiff, B. G.
Stevens, P. E.
Stratford, A. B.
Thomas, J. P.
Thompson, J. L., M.SC.
Timmis, A. C., B.SC.
Troutet-Mascart, F.
Twiss, G. V.
Ullman, E. A.
Waddell, J.
Wardale, W. T.
Watson, A. G.
Watson, A. H. St.C.
Weaver, H. G.
Wheeler, R., O.B.E.
White, E. S., B.SC.(ENG.)
Whitehorn, H. K.
Woods, J. A.
Woodward, Lt.-Col. E. H. E., C.B.E., M.C., T.D., B.SC.(ENG.)
Wright, J. H.

THE INSTITUTION CONVERSAZIONE

THURSDAY, 23RD JUNE 1960, LONDON

THE Council have decided in view of the undoubted success of the Conversaziones held at the Royal Festival Hall in June 1956 and 1958 to hold a similar function this year. This will take place at the Royal Festival Hall on Thursday, 23rd June 1960 from 7.30 p.m. until midnight. There will again be a wide range of electrical engineering exhibits and the programme will include a concert in the auditorium and dancing in the foyer; buffet refreshments will be available during the evening. Further details and an application form for tickets will be issued to members with the March 1960 *Journal*.

'THE ENGINEER—HIS DUE AND HIS DUTY IN LIFE'

IN view of the frequent references recently made to it, and particularly the quotation in Sir Willis Jackson's Presidential Address in October 1959, a number of members have expressed a wish to read the paper 'The engineer—his due and his duty in life' which was presented to The Institution in 1925 by the late Thomas Carter (*Journal I.E.E.*, 1926, **64**, pp. 193–200). Reprints have now been made and may be obtained from the Secretary of The Institution at the special price of 2s.

The following are the heads under which the subject is treated in the paper: the rights and the duties of life; the rise of modern engineering; the finding of engineers; the training of engineers; principles and problems; engineers and public life; and conclusion.

MEMBERSHIP PROPOSAL FORMS

A NEW method which will save much time and expense in presenting proposal forms 'E' and 'T' to the Membership Committee of the Council has recently been introduced.

For a time the old and the new systems will be working concurrently but it is hoped to handle all proposals in the new way as soon as possible. For this reason any candidate who may have partially completed one of the obsolescent proposal forms should write to the Secretary of The Institution for one of the new forms. Similarly a Proposer or Supporter who is asked to add his signature on one of the old forms should advise the candidate to write to the Secretary for a revised form.

If some of the requisite signatures have already been obtained on one of the earlier forms, the remaining signatures may be written on a revised form 'E' or 'T' and the candidate may set out his statement on one of the new forms 'EA' and 'TA', which are now issued as enclosures to the proposal forms, and send both forms to the Secretary. The confirmation of the statements appearing on the old form will then be accepted in confirmation of the equivalent sections in form 'EA' or 'TA'.

MEMBERSHIP OF LOCAL CENTRES AND SUB-CENTRES

A MEMBER whose registered address is within the area of a Centre or Sub-Centre is automatically attached to the Centre or Sub-Centre concerned, and also if he is a Student or a Graduate under the age of 28 to any Graduate and Student Section within the area. Any member who so wishes however may be attached to any Centre or Sub-Centre adjacent to that in which he resides, if this is more convenient to him,

by making a request in writing to the Secretary of The Institution to that effect.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notification of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested when notifying a change of address to give their full initials, the previous address and their class of membership.

INCOME-TAX REBATE ON MEMBERS' SUBSCRIPTIONS

IT is now well known that members may charge their annual Institution membership subscriptions as an expense against income before the deduction of income tax, provided that they have completed form P358. It may not be generally known that the Commissioners of Inland Revenue have also ruled that an additional subscription for the technical publications of a society which has been approved by them under the provision of Section 16 of the Finance Act of 1958 can be charged in a similar way by the members of that society. This was last reported on p. 556 of the September 1959 *Journal*.

The letter from the Senior Principal Inspector of Taxes to the Secretary of The Institution on this subject was dated the 20th August 1959 and bore the reference C.I./Sub/266/MCG, and this could be quoted if such a charge is queried by an Inspector of Taxes.

DISCUSSIONS AT MEETINGS

THE Council of The Institution desire it to be understood that contributions to the discussion at meetings should not be read from manuscript since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

MEMBERS who are unable to be present at a meeting or who if present do not have an opportunity of speaking may submit written contributions to the discussion which will be considered for publication in the *Proceedings* of The Institution.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

SCHOLARSHIPS 1960

THE Council of The Institution will consider these scholarships for award this year:

RESEARCH SCHOLARSHIPS

Oliver Lodge	value £420 for one year
I.M.E.A.	value £420 for one year
Swan Memorial	value £360 for one year
John S. Robinson Memorial Fund	value £350 for one year
Mervyn J. P. O'Gorman Memorial Fund	value £100 for one year
C. P. Sparks Fund	value £100 for one year

GRADUATE SCHOLARSHIPS (*for full-time postgraduate study*)

Duddell	value £400 for one year
Silvanus Thompson	value £400 for one year
John S. Robinson Memorial Fund	value £350 for one year
Mervyn J. P. O'Gorman Memorial Fund	value £100 for one year

STUDENT SCHOLARSHIPS

I.M.E.A.	value £210 for one year
Silvanus Thompson	value £200 per annum for three years
Duddell	value £200 for three years
W. B. Esson	value £180 per annum for two years
Paul	value £150 per annum for four years
Sir Arthur Fleming	value £120 per annum for four years
Salomons	value £120 for one year
David Hughes	value £120 for one year
John S. Robinson Memorial Fund	value £120 per annum for three years
Mervyn J. P. O'Gorman Memorial Fund	value £100 for one year
Thorrowgood	value £50 for one year

The Student Scholarships are awarded to candidates wishing to study at undergraduate level at a university or a technical college and may also be awarded to candidates pursuing an industry-based sandwich course in electrical engineering.

The closing date for the receipt of applications is the 1st June 1960. Application should be made for a Research, a Graduate or a Student Scholarship and not for a particular named scholarship.

Full particulars of the conditions governing the award of these scholarships and nomination forms may be obtained on request from the Secretary of The Institution.

CONVENTION ON MILITARY ELECTRONICS

THE Professional Group on Military Electronics of the Institute of Radio Engineers is sponsoring its 4th national convention on military electronics, to be held at the Sheraton-Park Hotel, Washington, D.C., U.S.A., from the 27th to 29th June 1960.

PORTRAIT OF THOMAS ALVA EDISON

THE Union internationale des télécommunications, in accordance with their annual custom of producing portraits of pioneers of communication engineering, have recently issued an engraving of Thomas Alva Edison, a reproduction of which is shown here. Pictures in this series, which are printed on art paper, measure 23 × 17cm (including margins) and may be obtained from the Secrétariat général of the Union, Palais Wilson, 52 rue des Pâquis, Geneva, at a price of 3 Swiss francs each, post-free. A short biography accompanies the portrait, of which 1000 copies only are being printed. A small number of reproductions are still available of the portraits of Ampère, Armstrong, Baudot, Bell, Erlang, Faraday, Ferrié, Fresnel, Gauss and Weber, Heaviside, Hertz, Hughes, Kelvin, Kirchhoff, Lodge, Lorentz, Marconi, Maxwell, Morse, Popov, Pupin, Rayleigh, Siemens and Tesla.

SUMMER SCHOOL IN HEALTH PHYSICS

FOR two weeks starting on the 4th July 1960 a summer school in health physics (radiation protection) will be held in the Nuclear Technology Laboratories forming part of the Department of Chemical Engineering and Chemical Technology, Imperial College of Science and Technology.

The course should be of interest to university radiation-protection officers, industrial safety officers concerned with radiation and radioactive hazards, medical officers of health, factory inspectors, and others concerned with radiation protection.

Residential facilities will be available at College hostels and the fee for the course is 25 guineas exclusive of residence. Applications for admission should be made to the Registrar, Imperial College, South Kensington, London S.W.7, from whom further information may be obtained.

RADIATION PROTECTION

THE second course in the principles of radiation protection is to be held at the Reactor School, Atomic Energy Research Establishment, Harwell, from the 20th April to 29th June 1960. The course is intended for people who are taking up work on health and safety problems in the nuclear field. It lasts for 11 weeks, the final week being earmarked for visits to the U.K.A.E.A. factories at Windscale, Calder Hall, Springfields and Capenhurst for the purpose of seeing at first hand the problems in health physics and safety there.

The course contains about 100 lectures under these three main headings: basic scientific principles, principles of radiation protection, and general topics.

The fee for the course is £250 and application forms may be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire. The closing date for applications is the 11th March 1960.

SCIENCE RESEARCH GRANTS

THE meeting of Heads of Governments of the North Atlantic Treaty Organization in December 1957 concluded that very serious efforts should be made by the NATO countries in the field of pure and applied science to keep up with the surprising development in the Eastern countries. Hence the Science Committee and the Office of the Science Adviser were created. In 1958 the NATO Science Fellowship Programme and the NATO Advanced Study Institute Programme were undertaken. In the first of these, students are sent from the NATO countries to study in other (mainly NATO) countries; and in the second, scientific seminars are subsidized.

On the 1st January1960 a third programme was established, the NATO Research Grants Programme, which began with a fund of $500000 supplied by the member-countries. The primary purpose is to promote increased co-operation in research among the member-nations and to a lesser extent for other scientific projects in which international aid is particularly desirable. The results of research encouraged under this programme will be made available to all member-countries.

Grants will be made for preparatory work in the field of natural sciences and technology which might lead to large co-operative projects and for smaller co-operative projects. To a lesser extent grants will be made to stimulate increased research in the less developed member-countries. The selection of the recipients of the research grants will be made by a Scientific Research Grants Panel.

Applications should be made to the Office of the Science Adviser, North Atlantic Treaty Organization, Palais de Chaillot, Paris 16e, France.

SIZEWELL NUCLEAR POWER STATION

THE Central Electricity Generating Board have been informed that the Minister of Power has decided to give his consent to the building of a nuclear power station at Sizewell, Suffolk.

With a planned output of 650MW, larger than that of any of the nuclear power stations now under construction, the Sizewell installation will help meet the increasing demand for power in Suffolk, Norfolk and adjoining regions.

Tenders are being sought from the consortia of companies engaged in nuclear-power-station construction work, and preparatory work will be carried out on local access-road improvement.

Four nuclear power stations are being constructed by the C.E.G.B., at Bradwell, Essex (300MW); Berkeley, Gloucestershire (275MW); Hinkley Point, Somerset (500MW) and Trawsfynydd, Merionethshire (500MW).

The C.E.G.B. have received consent for a fifth installation at Dungeness, Kent (500MW) and are seeking consent for a 1000MW station at Oldbury, Gloucestershire.

BULLETIN OF THE SECTIONS

SUPPLY

Forward plans

THE session is advancing and although its termination at Savoy Place is three months away, two major events will occur in May. On the 11th the Section will welcome Mr. G. Jancke who will deliver the Annual Lecture on 'The development of the 400kV network in Sweden'. Mr. Jancke is well known to many members and is recognized as an eminent authority in his field. The scheme, inaugurated only a few years ago, has enabled Swedish engineers to make a notable contribution to knowledge on e.h.v. transmission, and treatment of this subject will carry a high measure of interest.

For Saturday, 21st May 1960 the Section have planned a day visit to Cambridge when tours will be made of the Engineering Department and certain colleges. On a previous occasion a summer visit was made to Cambridge. Members will remember its excellence and undoubtedly, while wishing to renew their acquaintance with the city, will also urge colleagues to participate. Application forms will be sent to members of the Section in March. F. C. W.

Dirt and damp

NOVEMBER has the reputation of being the dirtiest and dampest month of the year and it was therefore appropriate that the 18th November 1959 should have been selected for the reading at Savoy Place of a paper by Dr. J. S. Forrest and Messrs. P. J. Lambeth and D. F. Oakeshott on 'Research on the performance of high-voltage insulators in polluted atmospheres'. An article based on the paper appears on p. 104. Dr. Forrest, in presenting the paper, remarked that this was the third instalment of a report on a series of tests of which the last instalment was given 17 years ago.

During the interval quite a lot of information had accumulated, and the performance of various types of outdoor insulator in the typical climatic conditions of this country was explained. It is hoped that industrial pollution which has been of the greater importance in the past will be lessened by the smoke-abatement legislation but the present practice of building generating stations on or near the coast is making pollution by seaborne salt more important. The synthetic tests described in the paper deal with salt rather than industrial pollution.

The discussion was opened by Mr. P. J. Ryle who referred to some work which he had done for a paper published in 1931. He reported the results of his own tests as 'interesting but inconclusive' and one is inclined to wonder whether the same remark might apply to the subject of the present paper.

M. Leroy mentioned the technique adopted by Électricité de France. They rely on field tests as well as station and laboratory tests.

Mr. J. A. Broughall pointed out that the supply industry has an easy problem compared with the railways, where steam locomotives bring their own pollution right onto the job. They are carrying out tests similar to those described in the paper and are considering the employment of a portable steam generator for cleaning insulators.

'Lubritorium'

Mr. D. M. Cherry complained that the scale of work was far too small. We do not yet know the best type of insulator for a given voltage. The use of grease or oil is only a palliative and the employment of conducting glaze is not yet on a production basis. Washing techniques must be developed further, and where the problem is acute or there are difficulties in making the switchgear dead for cleaning, indoor switchgear is necessary.

Mr. N. G. Simpson gave an account of cases in Aden and Karachi where the situation had been saved by the use of a silicone grease and Mr. W. G. Todd spoke about the 'lubritorium' at Littlebrook employed for the regular degreasing and regreasing of insulators at that station. There were a number of other speakers, some of whom suggested that experience showed we might use shorter tension strings.

Mr. Oakeshott explained that he had written his reply before the meeting but as, fortunately, the questions raised dealt with a number of points that he had already included in his answer, the correlation between questions and replies would be good. As far as he was concerned it was, and Mr. Lambeth replied to the other points. Nobody however had asked the authors why an insulator which is perfectly satisfactory when it is clean and dry flashes over when it is dirty and damp. They did not therefore have the opportunity of telling us.

After a vote of thanks, proposed by Dr. Mortlock from the Chair, we went out into the November night, which luckily was less dirty and damp than might have been expected from the pessimistic assessment of the British weather which was the reason for the paper anyway, hoping that less than 17 further years would elapse before we have the fourth instalment of this interesting report. J. L. E.

'Recapping' on encapsulation

THE Supply Section paper on low-pressure cast resins by Messrs. Manley, Rothwell and Gray read at the Ordinary Meeting at Savoy Place on the 26th November 1959 resulted in a lively and expert discussion, stimulated by the novelty and importance of the work described by the authors.

The paper included information on the properties of cast resins and on their application to the building of totally enclosed switchgear and to the design of instrument transformers.

The authors added some speculations on future uses of resin castings and some information on developments abroad.

The authors' frankness in discussing their 'teething' troubles and the means for overcoming them called forth similar frankness in the discussion which covered *inter alia* ways of avoiding cracking of the resin, the technique of testing for internal discharges, and the evaluation of resistance to tracking, besides numerous examples of the application of cast resin not only to medium- and high-voltage switchgear but in connection with cables, transformers and machines.

As might have been suspected there were sceptics and enthusiasts; on the whole the enthusiasts seemed to be in the majority. A fuller report of the meeting appeared in the January 1959 *Journal*, p. 56. C. J. O. G.

ELECTRONICS AND COMMUNICATIONS

Maser and medium meetings for March

On the 7th March 1960 Dr. P. N. Butcher will read at Savoy Place his paper entitled 'An introduction to the theory of masers with particular reference to the travelling-wave maser'. He will describe in simple terms how microwave amplification by stimulated electromagnetic radiation can be achieved in crystals such as the ruby and the emerald. In the travelling-wave maser the crystal is distributed along a waveguide. This technique provides a wide-band unidirectional amplifier with the excellent noise performance which is characteristic of masers.

Dr. Butcher was born at Ashford, Kent, in 1929. In 1951 he joined the theoretical physics division of the Royal Radar Establishment to work on problems relating to microwave valves. During 1956 and 1957 he spent 18 months in the electronics research laboratory at Stanford University where he studied the theory of travelling-wave tubes and masers. Since returning to the R.R.E. he has continued in the rapidly expanding field of maser research and in 1959 he was awarded the Kelvin Premium for his contribution to the subject.

Gazing into the crystal ball

On Wednesday, 23rd March 1960 Mr. G. Millington will give a lecture on 'The challenge of the propagation medium to the radio engineer'. Mr. Millington, who is a senior propagation engineer at Marconi's Research Laboratories and the Immediate Past-Chairman of the Section, will review the development of radio propagation from Maxwell to the present. He will endeavour to show that the propagation medium has presented a series of challenges to the radio engineer who has sought to develop world-wide communications, direction-finders, navigational aids and many other applications in this age of radio astronomy and space research.

Sometimes the medium has revealed itself as an aid to achieving what was thought to be impossible, as when it was found, first at very low frequencies and then at high frequencies, that the ionosphere permits world-wide communication, and when it was realized that both the ionosphere and the troposphere allow long-distance propagation by forward scattering.

The engineer has risen to the challenge to exploit the propagation medium by the development of techniques which have enabled the various frequency bands of the radio spectrum to be brought successively into use. The medium in its turn has put many difficulties in his way, confronting him with atmospheric noise, with polarization errors in direction-finding, with multipath and time-delay troubles in communication, and with all the complex variations in the structure of the ionosphere and troposphere leading to fading, high attenuation and anomalous propagation.

The engineer, with great ingenuity, has overcome many of these hindrances, using single-sideband transmissions, error-correcting codes and frequency-shift keying, to mention but a few of his devices. What further possibilities will the medium offer to the engineer and what obstacles will it place in the way of their achievement only to be overcome in due course?

It is hoped that many who have wrestled with the challenge in the past or are actively engaged in the fray will come along and contribute their reminiscences or help to gaze into the crystal ball of this space age in which propagation is destined to play such an important part.

Frequency selection

At Savoy Place on the 7th December 1959, with Mr. J. A. Ratcliffe in the chair, Mr. B. B. Jacobsen presented a paper on 'Frequency patterns for multiple-radio-channel routes' which is reviewed on p. 105. The meeting was well attended by an audience many of whom, judging by the subsequent discussion, had had personal experience of the problems concerned. The author gave a clear exposition of the complexities involved in producing a frequency-selection plan. Using a blackboard and chalk he explained some of the difficulties from first principles.

International application

Mr. Bray opened the discussion by complimenting Mr. Jacobsen on his solution to so difficult a problem. The fact that the C.C.I.R. had adopted the plan for international circuits was a measure of its success. The United Kingdom and many other countries were also using the plan within their own frontiers. He pointed out that the first international application of the plan was in fact to the link between this country and France for television which had been described in the Section Chairman's Address (see p. 96). Mr. Bray asked a number of questions and congratulated the author not only on his paper but on all the past work he had done on radio-relay and coaxial-cable systems.

There followed a lively period of discussion, question and answer, Mr. Jacobsen dealing in turn with the questions as they were posed. Among the interesting issues covered were the problem of distortion, the use of more-sophisticated aerial systems and the application of the plan to trans-horizon routes over mountainous country. The chairman in thanking the author for his excellent paper referred to the volume of the discussion compared to the length of the discourse which was a good index of the interest aroused. R. G. M.

'Electrons in action'

THE Section Committee commend to members a public exhibition entitled 'Electrons in action' which is to be held on the 21st and 22nd March 1960 at the Manchester College of Science and Technology and has been organized by the North-Western Electronics and Communications Group. It is designed to stimulate interest in electrical engineering, particularly among young people, and the Group have organized visits by parties of students from the university, technical colleges and grammar schools in the area.

The exhibition, which will be open from 10a.m. to 9p.m. on both days and to which admission will be free, will include exhibits and displays from industry and from academic institutions.

MEASUREMENT AND CONTROL

Annual Dinner

THE Section Dinner was held at the Café Royal, London, on the 10th November 1959 and was attended by 270 members and their guests.

Following the loyal toast, members witnessed some astonishing examples of Chinese deftness by Ming Chow, the entertainer. Several discovered that their wrist-watches, wallets and diaries had vanished and were doubtless relieved when the *status quo* was at last restored.

After this disturbing but amusing episode the President, Sir Willis Jackson, in an intimate and friendly speech, referred to the evolution of the Section and how its scope had broadened in recent years. He thought it would be a mistake to attempt too rigid a definition of the scope. In proposing the toast of the Section he was happy to associate with it the name of the Chairman, Prof. A. Tustin, in whose guidance the Section could have every confidence.

Visit to Russia

In his reply Prof. Tustin remarked that the Section, although relatively small, nevertheless had an important part to play in the life of The Institution. He related some of his experiences on his recent visit to Russia to study automatic control in industry. He warmly welcomed the Chairmen of the three other Sections; Mr. P. H. Spagnoletti, who had been host on the Section's summer visit in June 1959; and Prof. R. F. Woolmer, Director of Research, Department of Anaesthetics, Royal College of Surgeons of England. The presence of Prof. Woolmer was an indication of the Section's interest in the rapidly growing sphere of medical electronics.

Dr. G. B. B. M. Sutherland, Director of the National Physical Laboratory, replied to the toast of 'Our guests'. On a previous more formal occasion members had had the privilege of hearing Dr. Sutherland deliver the Kelvin Lecture and must have been impressed by his treatment of his subject. They were now regaled with an intimate account of the latest developments at the N.P.L. which is surely the home of all that is best in the subject of measurement and control.

J. K. W.

Transformers versus networks for operating fault-protective circuits

THE Section met at Savoy Place on the 17th November 1959, with Prof. A. Tustin in the Chair, to discuss the deceptively simple-sounding question of whether fault-detecting relays for differential protection may most advantageously be operated from summation transformers or from sequence networks. The topic was introduced by Mr. C. Adamson and Dr. E. A. Talkhan.

The problem was presented and dissected with great clarity by Mr. Adamson who showed curves giving the variation of relay excitation obtainable by sequence networks in various fault conditions as functions of resistance and inductance ratios. His analysis appeared to be complete in the sense that, if one knew what one wanted, one would know what arrangement would most nearly approach the requirements. The uninitiated might have thought that all was said and that discussion might be confined to minor elaborations of Mr. Adamson's masterly thesis.

But how mistaken we were! The experts soon showed that the matter was not so simple. Mr. M. Kaufman led the assault in a long and highly technical discourse on aspects of the matter that he thought Mr. Adamson had insufficiently explored. What about the effect on carrier systems? Must the same scheme be used at both ends of the line? Would the theoretical advantages of sequence networks in practice justify their greater complication? His conclusions, other than the general one that life was very complicated, were somewhat obscure but he seemed to be putting his weight on the transformer side of the balance.

Degrees of freedom

Mr. A. P. Thoms continued by displaying the significance of the frequency variations that may well accompany the occurrence of fault conditions. He showed that a 6% drop in frequency might radically change the comparative behaviour of various schemes. The next speaker, Mr. S. Rudzinski, showed that there may be other solutions than a choice between the two under discussion. He described a device, now under experimental development, in which the detecting element is a small synchronous machine. The e.m.f. in a rotor winding is normally zero but a zero or negative phase-sequence component produces a proportional double-frequency output. He showed experimental results, using a Magslip as a detector, on the behaviour of this device in transient conditions.

Mr. J. W. Hodgkins put the basis of the difficulty with fundamental clarity. Three vectors have six degrees of freedom. Hence no single-phase quantity, with its two degrees of freedom, can be made, by any device whatever, to convey complete information about the state of a 3-phase system. He thought that the basic difference between the transformer and

the sequence network was that the former always had equal sensitivity to positive and negative phase sequences while the latter gave possibility of choice. His conclusion was that the summation transformer has the advantage of simplicity and is better on transients. Mr. W. Fordham Cooper supported Mr. Hodgkins in his reference to degrees of freedom and illustrated by a simple diagram that there must always be some hypothetical fault that could not be detected.

Other speakers continued a vigorous discussion. Dr. Talkhan replied for both the openers. He illustrated the effect of the nature of the load on the sensitivity of the various schemes, and the relationship between amplitude and phase.

The material presented during this discussion was of great practical value and it is to be hoped that much of it will become available in a more permanent form. A. T.

Data-handling problems in atomic installations

DATA-HANDLING and atomic installations are both subjects with glamour and they combined to form the basis of a lively discussion at Savoy Place on the 15th December 1959.

Dr. Denis Taylor opened by calling attention to the many measurements of flow, pressure and temperature which are required to operate a nuclear power station or other atomic installation in addition to those of nuclear activity. Developments are now taking place involving the provision of data-handling systems which watch the measurements produced by the instruments and call the attention of the control engineer only to any abnormality in the readings, with the additional facility of being able to check the sequence of events leading to this abnormality if required.

Similarly elaborate data-processing systems are being proposed for other types of plant, notably those for isotope separation. At present a complete system covering all the measurements of any large installation by one unified apparatus is still a long way off, and data-handling and data-processing systems have been used in nuclear power stations so far only with limited objectives. Thus one organization is building a data-processing system for the burst-slug-detection system at the C.E.G.B. nuclear power station at Berkeley. Another application is in handling the data obtained from the several hundred thermocouples employed in the core of the large gas-cooled reactor.

Mr. J. Churchill gave further details of the burst-slug-detection equipment in which a parameter corresponding to the fission-product activity for each channel is counted with a scaling circuit and is passed as a binary count to a digital computer which stores the information. Logic processes are necessary to evolve the treatment of this information which is most likely to reveal the presence of a burst fuel-element.

Mr. E. H. Cooke-Yarborough gave an interesting analysis of the data-presentation gear used at Harwell to obtain the best return possible on the capital investment in a large linear accelerator. The equipment analyses the spectrum of particle energies in various experiments. By recording the vital statistics of an experiment on magnetic tape for later analysis it is possible to avoid tying up very expensive equipment for the whole of the experiment time and to deal with quantities of readings which it would be beyond the experimental staff to analyse during the experiment time.

Fault memory time

Mr. J. Golder emphasized that the reliability of data-presentation gear will have to be very high if it is to be used for safety or protection purposes. Performances of 99·5% availability are just not good enough. The sort of reliability obtained in submarine cables is the standard required, preferably without the accompanying high price. The U.K.A.E.A. are using several installations of slow safety-scanning equipment for process-plant monitoring. This represents the first of three broad systems, the others being data-handling with such facilities as rates-of-change computation, and data-processing with very fast operating times used for process control.

Mr. J. Roth gave some details of data-scanning equipment operating at 350 points per second and Mr. N. T. C. McAffer was anxious to encourage the idea that data-processing should not be used for one set of parameters but should be developed for employment as a whole station-monitoring facility.

Mr. R. D. Trotter stressed that operators of large plants would have to be convinced of the true value of data-presentation equipment of any type before they would consent to change from present practices. In slow-response base-load plant the use of data-processing is primarily intended to supersede recorders. The latter produce large quantities of paper in normal conditions but following fault conditions the amount of information available is on far too small a time-scale for use.

He suggested that a fault memory time of 30sec prior to the fault and 30sec after the fault would be the sort of time-span to be covered, and fast scanning of this period of time would be useful only if the measuring instruments feeding the data-processing gear were capable of high speeds of response. This does not apply to many ways of measuring, say, pressure and temperature at present. The attractions that this type of equipment might have for operators could be first that more-efficient running of plant would be possible because parameters are more closely monitored; secondly that increased safety might be achieved; and thirdly that lower over-all cost might be possible when the correct allowance is made for operating and maintenance safety changes.

Mr. F. A. Drake spoke of the experience being gained in the United States on data-presentation equipment. There the point has been reached where the apparatus is available off the shelf. The limiting factor in many applications is the stability of d.c. amplifiers for low-level signals. Ingenious print-out devices capable of 3000 words per minute are possible using magnetic techniques and the Americans seem fully convinced on the use of data-presentation from the point of view of saving operators and hence saving money.

Mr. G. L. Law crystallized the attitude of many other speakers in calling for reliability factors of 99·995% as representing the only sort of reliability acceptable.

Dr. Taylor in summing up said that it would appear that the future application of these machines in this country was not yet clearly defined. Manufacturers would therefore be well advised to develop very flexible machines. R. D. T.

UTILIZATION

Protection of semiconductor rectifiers

THE meeting at Savoy Place on the 10th December 1959, which attracted a large audience among whom there were a considerable number of younger members, was devoted to a stimulating paper entitled 'The characteristics and protection of semiconductor rectifiers' presented by D. B. Corbyn and N. L. Potter. The paper is reviewed on p. 102. Mr. T. E. Houghton was in the Chair.

In the course of their remarks the authors pointed out that semiconductor systems are susceptible to damage by overcurrent and overvoltage and that their advent, which has involved a steady supplanting of conventional methods of rectification over a very wide field in industry, has created completely different protective requirements which must be properly applied if advantages are to be fully realized. They also discussed the use of special h.b.c. fuses in this connection and showed the necessity for the co-ordination of various forms of protection in order to ensure satisfactory operation. Details were given of the individual protective measures required for certain types of load.

Fit and forget

The discussion, in which many took part, was opened by J. A. Broughall of British Railways, who expressed the view that the railways wanted instruments which were completely reliable and as simple as possible. He hoped that progress would be such that it would be possible to regard the semiconductor rectifier as a switch, i.e. giving protection but not requiring protection itself. The position should be reached, he said, when rectifiers could be installed and then forgotten. As he rather succinctly put it, it was better to put money into cells than into gadgets.

A speaker from the manufacturing side of the industry however was of the opinion that it would be some time before the semiconductor rectifier would possess the inherent qualities of self-protection, and openly confessed that in many applications it could function reliably only 'with a bodyguard trailing along behind it'; while another contributor remarked that the saving effected by omitting d.c. circuit-breakers on very large equipments was not big enough to justify taking the risk of damage occurring.

The importance was stressed of the user and the manufacturer speaking the same language as regards the technical terms used.

The general impression one gained from the discussion was that there is a significant consensus of opinion concerning the desirability of retaining as simple a system of protection as possible and that more energetic steps should be taken to combat the present trend of installing so many ancillary devices.

R. H. R.

The Christmas Holiday Lecturer, Mr. G. G. Gouriet, shows some of his audience the apparatus used in his demonstrations. His subject was 'Colour television' and the photograph was taken in the Lecture Theatre at Savoy Place after the delivery of the Lecture in the afternoon of the 31st December 1959 *(see p. 100)*

News from the Centres

WEST WALES (SWANSEA) SUB-CENTRE

Annual General Meeting

WHEN Mr. T. Gill, Chairman of the Sub-Centre, presided at its Annual General Meeting on the 24th September 1959 he gave an interesting report on activities during the previous year. Attendance at the meeting was fair, but all present were glad to hear about the full programme which had been completed.

Mr. Gill touched on the membership of the Sub-Centre; the meetings of the Committee; the attendance of members and visitors at Ordinary Meetings and at the District Meeting at Tenby; the variety of well selected papers read; the Faraday Lecture given to two gatherings, comprising an afternoon audience of 1486 secondary-school children and a public evening session attended by 1100 people; the Dinner-Dance where Mr. G. S. C. Lucas, a Vice-President, responded to the toast of The Institution; the showing of The Institution's film 'The inquiring mind' to three school audiences; the financial position of the Sub-Centre; and the collection for and the grants made from the Benevolent Fund.

The report was received with acclamation, and following a discussion on it, a film on nuclear energy was shown.

Induction of new Chairman

In the course of the meeting of the Sub-Centre Committee held on the 8th October 1959 Mr. T. Gill vacated the Chair in favour of Mr. J. Harley, the new Chairman. Mr. Gill thanked the members of the Committee for their support during his year of office. Mr. Harley then took the Chair and in turn thanked Mr. Gill on behalf of the Committee for the work he had done during the past session.

At the Ordinary Meeting of the Sub-Centre which followed, Mr. Harley gave his Address entitled 'Électricité de France' which was based on his studies and experiences in that country and was illustrated by a magnificent coloured film. An article based on part of the Address will be published shortly in the *Journal*.

Lighting and architecture

At a meeting held on the 10th December 1959 under the Chairmanship of Mr. J. Harley a paper entitled 'Lighting and architecture' was read by Mr. J. M. Waldram, a Past-President of the Illuminating Engineering Society (see p. 90). The meeting was an appropriate one during the Golden Jubilee year of the Society. Moreover it was pleasing to see the Swansea Group of the Society so well represented, for the selection of the paper and the invitation to Mr. Waldram to visit Swansea were the result of the Sub-Centre's collaboration with them. Listening to the paper it became obvious that lighting, as a subject, is not for the engineer alone, but for the physicist, the chemist, the physiologist, the oculist, the architect, the artist and for everyone who has eyes to see.

In a masterly reading of an informative paper the author gave some colourful illustrations by way of lantern slides of the history, development and technique of lighting in the home, office and church. The outstanding part dealt with the recent lighting of Gloucester Cathedral by the 'designed appearance' method in which he had played an important part; and the slides showing the results of the application of that technique to the cathedral with its large and complex interior, consisting of several interconnecting spaces, were most impressive. Here too was an example of the 20th-century artist in lighting enhancing the work of the medieval artist in stone by painting with light the interior of that noble English cathedral—which has a Welshman as its Dean.

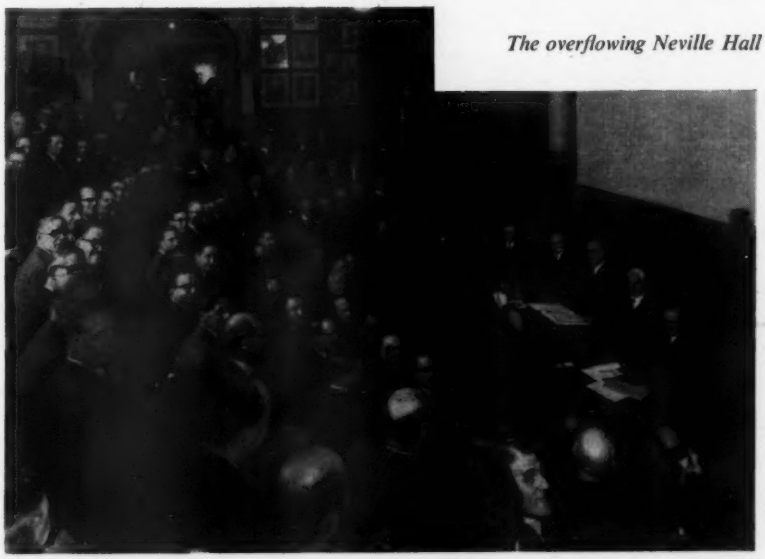
The discussion and questions after the reading clearly indicated that, following the example of Leonardo da Vinci, we should all aim to be artists as well as engineers. A. E.

NORTH-EASTERN CENTRE

Diamond Jubilee Meeting

THE meeting at Neville Hall, Newcastle upon Tyne, on the 14th December 1959 celebrated the Diamond Jubilee of the Centre, the petition for the formation of the 'local Section' having been signed on the 13th December 1899 and approved by the Council the following day.

The Chairman at the Jubilee Meeting, Mr. H. Watson-



The overflowing Neville Hall

Jones, welcomed the President, Sir Willis Jackson, Mr. J. R. Beard, a Past-President, the Secretary, Mr. W. K. Brasher, and nine members of the Committee of the Scottish Centre which celebrated its Diamond Jubilee on the same day.

Mr. Beard, who was Chairman of the Centre in 1920–21, gave the Diamond Jubilee Address entitled 'Their achievement —our inheritance'. Mr. B. A. Robinson moved a vote of thanks to Mr. Beard.

The Chairman then asked the President to accept on behalf of The Institution an attendance-register desk for the entrance to the new Lecture Theatre at Savoy Place, which would serve as a permanent reminder of the Jubilee. (The Scottish Centre is presenting the other half of the pair.)

Sir Willis Jackson, in expressing his pleasure in accepting the gift, likened the corporate body to a family comprising the old and new Centres. The Council's thanks were due as much for the co-operative spirit shown by the Centre as for the material value of the gift.

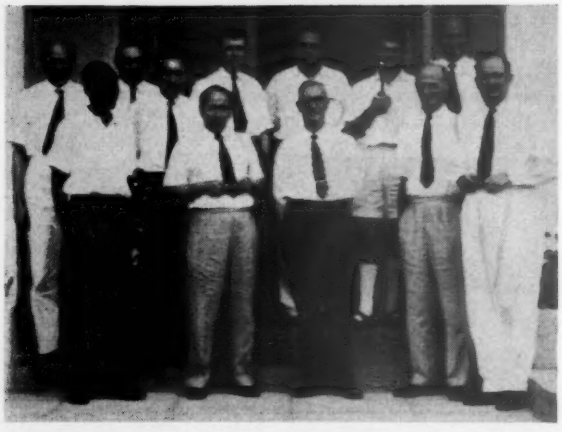
The President accepts the desk

News from abroad

GHANA JOINT GROUP

Visit of President and Secretary of Institution of Civil Engineers

ON the 22nd September 1959 the Group Chairman, Mr. T. C. M. Wigg, together with the Vice-Chairman, Honorary Secretary, and two representatives of the Ghana Government, and their ladies, were at Accra Airport to welcome Prof. A. J. S. Pippard, then President of the Institution of Civil Engineers, and Mr. A. McDonald, Secretary, and their ladies to Ghana for a week's visit.



Ghana Joint Group Committee, September 1959, with Prof. Pippard and Mr. McDonald

A full programme had been arranged during which the I.C.E. President and Secretary met the Prime Minister, Dr. Nkrumah, and the Ministers and officials responsible for works, communications and technical education. The visitors also saw some of the works in progress of the Public Works Department and visited the Volta River Scheme site.

One whole day was spent at Tema seeing the new harbour there and the development of the new town of Tema. The visitors also spent a day at Kumasi where they saw the College of Technology and had discussions with the Principal, Dr. W. E. Duncanson.

On the Saturday of their visit Prof. Pippard and Mr. McDonald toured the University College of Ghana, near Accra, and in the evening were the guests of the Group at the Annual Dinner, held this year in Akuafo Hall, University College of Ghana.

On the last day the Group Committee were honoured by the presence of the I.C.E. President and Secretary at their monthly meeting. C. D. W.

SINGAPORE/MALAYA JOINT GROUP

Annual Dinner

THE Group's Annual Dinner took place at the Lake Club, Kuala Lumpur, on the 21st November 1959. Official guests included the Minister of Transport; the Vice-Chancellor of the University of Malaya; the Chief Engineer, Armed Forces, Federation Army; the President of the Institute of Engineers, Federation of Malaya; the President of the Federation of Malaya Society of Architects; and the Chairman of the Royal Institution of Chartered Surveyors, Federation of Malaya Branch.

After the loyal toast the Chairman, Mr. S. E. Jewkes, spoke of the practical work of engineers as compared with the more theoretical work of other people. Mr. J. Sharples proposed the health of the guests and Dr. A. Oppenheim, the Vice-Chancellor of the University of Malaya, replied.

After dinner there was dancing to the music of the band of the Royal Federation of Malaya Police until 1 a.m. T. C.